INSTRUCTION MANUAL

model 135A
PULSE GENERATOR

E-H RESEARCH LABORATORIES, INC.

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PULSE GENERATOR

Serial No. _____

February 1972

E-H RESEARCH LABORATORIES, INC.

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(B) Printed in U.S.A. 148-07118

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b. Details concerning the nature of the malfunction.

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Figure 1-1 Model 135A Pulse Generator

SECTION 1
SPECIFICATIONS

1-1 HOW TO USE THIS INSTRUCTION MANUAL

Each section of this manual begins with a general description of the instrument oriented toward the subject matter in that section. Section 1 contains the electrical and mechanical specifications for the instrument. For the operator, Section 2 contains a complete description of controls and procedures. In Section 3, the theory of operation is described.

The schematics are located at the back of the manual. Section 6, in which the schematics are located, also contains assembly drawings of the printed circuit boards and other subassemblies. Individual components are identified on these drawings. For purposes of replacement, components and subassemblies are completely described in the parts lists in Section 5.

Section 4 contains maintenance and alignment procedures. It is strongly recommended that the repair technician read Section 3 and become familiar with the location of the various types of information in this manual before attempting any of the procedures in Section 4. Techniques are oriented strongly toward preventive maintenance and include routine visual checks, voltage and signal tests, and general notes on the use of test equipment with this instrument.

1-2 GENERAL INFORMATION

The Model 135A is a fast risetime backmatched, pulse generator providing a variable output pulse up to ± 10 V into a 50-ohm load with transition times of 3 ns to greater than 8 ms at ±10 V. Pulse repetition frequency is continuously variable from 10 Hz to 50 MHz from an internal clock and from zero to 50 MHz using an external trigger source. Pulse width is variable from less than 10 ns to 50 ms with coarse and fine controls. Delay of the output pulse with respect to the trigger output is varied by front-panel controls from 10 ns to 50 ms. The output may be gated by an external signal to provide synchronous pulse bursts.

The Model 135A is housed in a rigid, heavy duty cabinet suitable for bench-top use. Rack mounting is available as an option. Internal circuitry is solid state. Conservatively rated components and internal forced-air cooling provide reliable operation and long service life.

Applications of the Model 135A include testing of fast semiconductor devices, time domain reflectometry, cable, cable and delay line testing, and wide-band amplifier testing. Output waveform distortion is less than 5%, providing pulses which are free from troublesome overshoot and ringing.

1-3 SPECIFICATIONS (All specifications assume a 50-ohm resistive load on the output.)

a. Pulse Repetition Frequency. 10 Hz to 50 MHz from an internal clock. Zero to 50 MHz when driven by an external trigger source. The internal repetition rate is controllable in 14 ranges. A fine control gives continuous adjustment in each range.

b. Output Pulse Amplitude. ±30 mV to ±10 V into 50 ohms by the use of the attenuator and its associated FINE control.

c. Rise and Fall Times. (10% to 90%). From 3 ns to greater than 8 ms at 0 V to ±10 V. 10:1 vernier control.

d. Pulse Width. 10 ns to 50 ms continuously variable by coarse range selector and fine control.

e. Pulse Delay. 10 ns to 50 ms continuously variable by coarse range selector and FINE control.

f. Duty Factor. Greater than 50% in positive and negative normal polarities; effective duty factors approaching 100% in inverted polarities depending on pulse width.

g. Waveform Distortion. Less than 5% pk-pk at 10 V. 5% pk-pk at 3 V and with both 3 ns and t_r and t_f. 9% pk-pk at 3 V and minimum t_f and t_r.

h. Jitter. 0.1% ±50 ps including repetition frequency, width and delay jitter.

i. External Trigger Input. Requires -1.0 V to +1.0 V. Maximum input ±15 V. Requires minimum input of ±1 V.

j. Synchronous Gate Input. Requires ±2 V minimum, maximum of ±15 V. Switch selection of gated on, gated off, or normal.

k. Trigger Output. +1.5 V or 0.15 V into 50 ohms switchable. Width variable from 10 ns to 50 ns, positive or negative polarity.

l. Baseline Offset. 0 to ±5 V into 50 ohms continuously variable by fine control and switchable to either polarity or off.

m. Double Pulse Operation. Single or double pulse, switch selected. Double pulse frequency to 25 MHz.

n. Single Cycle Operation. One output cycle (single or double pulse) when the frequency switch is set to external and the front-panel pushbutton is pushed and released.

o. **Power Requirements.** 90-100, 105-125, 180-220, 210-230 Vac, 50-60 Hz.

1-4 ACCESSORIES

The following accessory is recommended for use with the Model 135A.

a. **Model 935 Scope Calibration Kit.** This accessory kit is used with the Model 135A to calibrate sampling oscilloscopes or for verifying calibration.

SECTION 2
OPERATING INFORMATION

2-1 GENERAL

The performance specifications require that the Model 135A operate into a 50-ohm resistive load. Any other load impedance will cause some distortion of the output waveform. Loads with a capacitive or inductive component will have an appreciable effect on the leading and trailing edges of the output pulses.

2-2 CABLES, CONNECTORS, and ATTENUATORS

The fast risetime output of the Model 135A Pulse Generator contains frequency components in excess of 500 MHz. If any of these high-frequency components are attenuated or distorted by the use of connectors, cables, or attenuators that do not have a flat frequency response materially beyond 500 MHz, degradation of the pulse waveforms will result. Reflections from mismatches will also degrade the pulse waveforms. For optimum results, good high-frequency signal-handling techniques are necessary in coupling the output of the Model 135A to the system or device under test.

Some of the precautions to observe when coupling the output of the Model 135A are:

(1) The output is backmatched with 50 ohms and the step attenuator is a constant 50-ohm impedance, hence the source impedance is a constant in all cases. The output can be operated into an open circuit or any other impedance from 50-ohm to infinity, but care must be taken to ensure that the sum of the offset and amplitude does not exceed ±18 V. The output pulse can also be operated into impedances less than 50 ohms. (i.e., short circuit) but with restrictions. The OFFSET must be OFF. At full amplitude, duty cycles must be less than 50% in NORMAL modes and greater than 50% in INVERTED modes, i.e., the output current should be at a high level less than 50% of the time. At half amplitude the current can be at a high level nearly 100% of the time. This restriction is linear between these two boundary conditions.

(2) Make sure that all connectors, cables, attenuators, etc. in the signal-handling path have a flat frequency response materially in excess of 500 MHz. Observe the power dissipation ratings of terminations and attenuators.

(3) Use only high-quality 50-ohm coaxial cable, such as RG-213/U with properly matched connectors. Keep cable lengths as short as possible, since long lengths of even high-quality coaxial cable attenuate high frequencies.

2-3 OPERATING CONTROLS and CONNECTORS

a. **FREQUENCY.** Selects one of 14 internally generated repetition-rate ranges or the external drive function. The repetition-rate range limits are in a 1-3-10 sequence from 10 Hz to 50 MHz.

b. **FINE (FREQ.)** A 3:1 vernier control which continuously varies the internally-generated repetition rate within the selected repetition-rate range, with overlap to the two adjacent ranges. In the DOUBLE PULSE mode, the FINE control is disconnected on the highest FREQ. RANGE, and the maximum repetition frequency is limited to 25 MHz

c. **EXT. TRIGGER INPUT Connector.** When the FREQUENCY control is in either + EXT or - EXT position

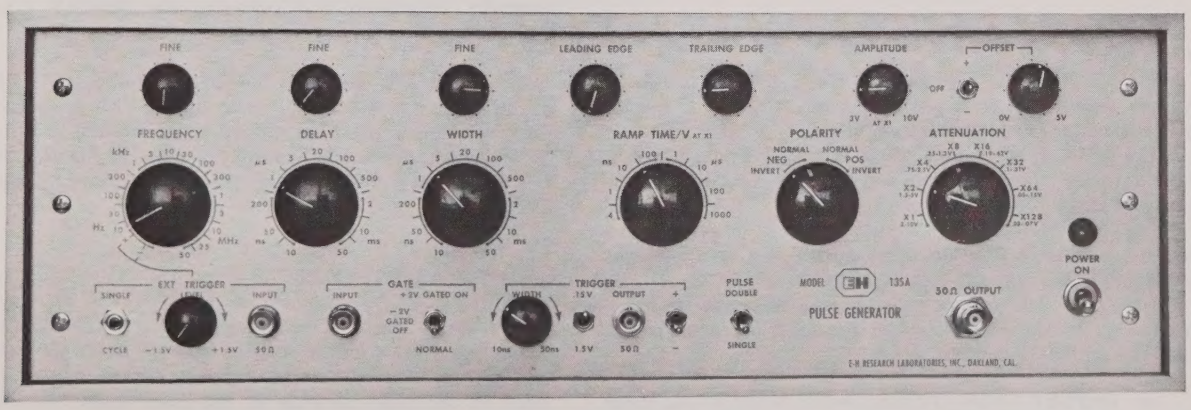


Figure 2-1 Model 135A Front Panel

the instrument may be triggered externally from 0 to 50 MHz. The external triggering signal must have an amplitude of ±1.0 volts or greater. The LEVEL control selects the point on the trigger waveform at which the Model 135A triggers. Input impedance is 50 ohms.

d. **DELAY.** Selects one of 10 delay ranges where the delay is the time interval between the leading edge on the trigger pulse and the leading edge of the output pulse. The delay range limits are in a 1-5-20 sequence from 10 ns to 50 ms.

e. **FINE (DELAY).** A 5:1 vernier control which continuously varies the delay interval within the selected delay range, with overlap to the adjacent ranges.

f. **WIDTH.** Selects one of 10 output-pulse width ranges. The pulse width range limits are in a 1-5-20 sequence from 10 ns to 50 ms.

g. **FINE (WIDTH).** A 5:1 vernier control which continuously varies the output pulse width within the selected range, with overlap to the two adjacent ranges.

h. **GATE.** A positive pulse or level with a minimum amplitude of the +2.0 volts will gate the internal clock on for the duration of the gate with the gate switch (marked––+2 V GATED ON––-2 V GATED OFF––Normal) in the +2 V GATED ON position. A negative pulse or level with a minimum amplitude of -2 volts will gate the internal clock for the duration of the gate with the gate switch in the -2 V GATED OFF position. When the gate switch is in the normal position a gate input signal will not affect the operation of the internal clock. The input impedance is 510 ohms.

i. **RAMP RATE/V at X1.** Selects one of 7 pulse leading and trailing edge slope ranges. The risetime and falltime of the output pulses have a constant slope, and these ranges state the slope of such a pulse at X1 attenuation. Each range position indicates the nominal slopes, but there is overlap between ranges.

j. **LEADING EDGE.** A 10:1 vernier control which continuously varies the output pulse leading edge slope with overlap to the two adjacent ranges.

k. **TRAILING EDGE.** A 10:1 vernier control which continuously varies the output pulse trailing edge slope, with overlap to the two adjacent ranges.

l. **POLARITY.** Selects one of 4 polarity modes for the output pulse.

(1) +NORMAL. The output pulse is positive-going from a ± baseline set by the offset control to a ± pulse top set by the amplitude and attenuator control.

(2) +INV. The output pulse is negative-going from a ±baseline set by the amplitude and attenuator controls to a ± pulse top set by the offset control.

(3) -NORMAL. The output pulse if negative-going from a ± baseline set by the offset control to a ±pulse top set by the amplitude and attenuator control.

(4) -INV. The output pulse is positive-going from a ± baseline set by the amplitude and attenuator controls to a ± pulse top set by the offset control.

m. **OFFSET.** Adds a dc component to the output pulse waveform after the output attenuator. The dc component is continuously variable from 0 V to ±5 V. The dc component is independent of pulse amplitude. The offset switch also has a zero offset position.

n. **ATTENUATION.** Selects one of four resistive attenuation ratios or a straight trhough connection between the pulse generator and the output connector. The attenuation ratios are: 1:1, 2:1, 4:1, 8:1, 16:1, 32:1, 64:1, and 128:1.

o. **AMPLITUDE.** Continuously varies the pulse amplitude before the attenuator, between the limits of 3.0 V and 10 V. This control, together with the attenuator, provides continuous adjustment of the pulse amplitude at the output connector from 30 mV to 10 V.

p. **OUTPUT Connector.** The output connector supplies the output pulse train to the external load.

q. **TRIGGER OUTPUT Connector.** Provides a ±1.5 V trigger output pulse into a 50-ohm load. The leading edge of the trigger pulse defines the beginning of the delay interval.

r. **TRIGGER WIDTH.** Provides continuous adjustment of the TRIGGER OUTPUT pulse width from 10 ns to 50 ns.

s. **TRIGGER POLARITY.** Provides for the selection of a positive or negative trigger output.

t. **TRIGGER ATTENUATOR.** Provides a selection of the trigger amplitude either 1.5 volts or 0.15 volts.

u. **PULSE MODE**

(1) In the SINGLE position, there is one output pulse during the pulse repetition period, occuring at a time interval after the trigger output pulse determined by the delay controls.

(2) In the double pulse position, there are 2 identical output pulses during the pulse repetition period, one at the beginning of the delay interval, and the other occuring at a time interval after the trigger pulse determined by the delay controls. Maximum repetition frequency for the double pulse operation is 25 MHz. Minimum spacing between the double output pulses is 50% of range width minimum or 15 ns, whichever is greater. Spacing between first and second pulse in the double pulse mode is determined by the setting of the delay controls.

v. **SINGLE CYCLE.** When the FREQUENCY control is in the EXT position, a single cycle can be initiated by manually depressing and releasing the SINGLE CYCLE pushbutton.

w. **POWER.** With the line cord connected to 115 vac, 50/60 Hz power source, and with the POWER switch set on its ON position, power is applied to all internal circuits and the POWER indicator light turns on. With the POWER switch set to its OFF position, all power is removed from the instrument.

2-4 OPERATING NOTES

a. **Duty Factor Considerations.** For optimum results, the selected pulse width plus the selected delay time should be less than the selected repetition-rate period. When the sum total of the time intervals in the pulse train exceeds the repetition-rate period, the interval-determining multivibrators may not have time to recover to a stable condition before

being retriggered. Erratic or unpredictable pulse trains may result.

b. Pulse Widths. The selected pulse width should not significantly exceed 50% of the repetition-rate period. For duty factors greater than 50%, invert the output pulse with the POLARITY control. In the INV position of the POLARITY switch, the WIDTH control determines the interval between pulses. The output pulse width then becomes the repetition-rate period minus the interval selected by the WIDTH control. With the WIDTH controls set to minimum, and the POLARITY control in the INV position, the duty factor is 10 ns less than 100%.

c. DC OFFSET. The OFFSET control is a variable dc current source which adds from 0 to ±200 ma to the output after the attenuator. This current source is independent of the pulse output.

2-5 210-250 VOLT OPERATION

The Model 135 is supplied with internal transformer power supplies. The primary windings are wired for 115 V power lines. For use with 220 V power lines, the transformer primaries must be rewired. Refer to the power supply schematic in this manual for the proper connections.

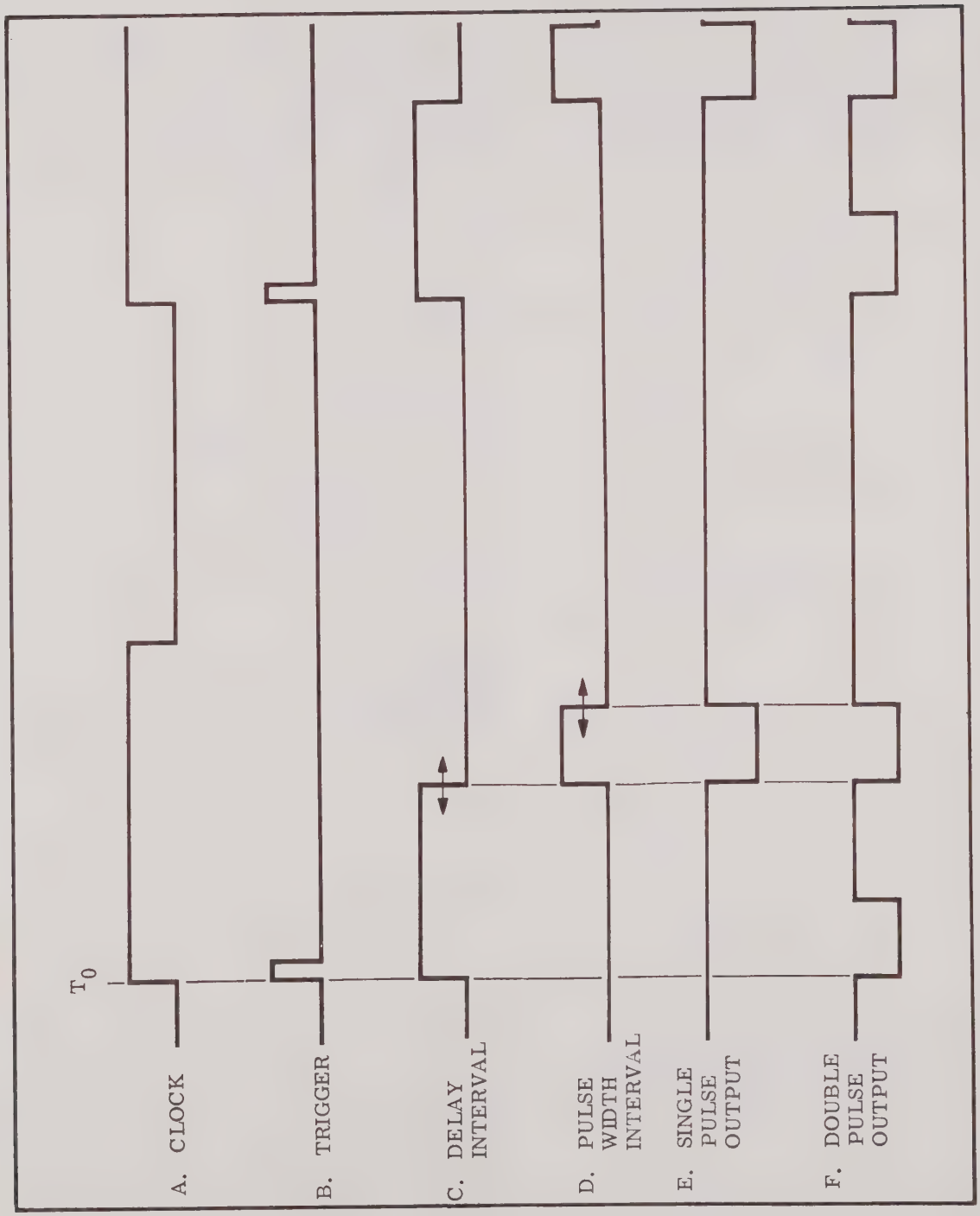


Figure 3-1 Timing Logic

EH-L0080

SECTION 3
THEORY OF OPERATION

3-1 GENERAL INFORMATION

This section of the manual contains an electrical description of each circuit in the Model 135A Pulse Generator. A block diagram is included in the drawings section showing the overall relationship of the various circuits. Schematic circuit numbers are used to identify components in the circuit descriptions. Refer to the specific schematics in the drawing section to supplement the following discussion.

3-2 CIRCUIT LOGIC

a. **General.** The timing logic in the Model 135A is determined by three multivibrators; the clock multivibrator, the delay multivibrator, and the width multivibrator. Each of the three multivibrators have independently variable periods determined by panel-mounted controls. The relationship of the three multivibrators is illustrated by waveforms A, C, and D of Figure 3-1.

b. **Clock Multivibrator** The clock multivibrator can operate free-running or gated. The operation of the clock multivibrator is dependent on the position of the FREQUENCY switch, and the waveforms applied to the GATE INPUT.

When the FREQUENCY switch is in any position other than ± EXT. the clock multivibrator free-runs at a repetition frequency determined by its panel-mounted controls. The pulse train may be modified by a gating signal of either +2 V or -2 V. The maximum GATE signal is ±15 V.

When the FREQUENCY switch is in either of the external drive positions the internal clock is disabled. The external drive signal triggers a Schmitt trigger circuit which in turn keys the delay and trigger circuits of the Model 135A. The Schmitt trigger circuit provides one output for every input from the EXT drive connector or each time the SINGLE CYCLE button is pushed and released.

In any of its modes of operation, the output from the clock multivibrator keys the trigger circuit and the delay multivibrator.

c. **Delay Multivibrator.** The delay multivibrator determines the time interval between the trigger output and the pulse width interval. The delay interval is keyed by the output from the clock multivibrator and the output from the delay multivibrator in turn keys the pulse width multivibrator.

d. **Width Multivibrator.** The pulse width multivibrator defines a time interval in the pulse train beginning at the end of the delay interval. Depending on the POLARITY and OFFSET controls, the pulse width interval can define the OUTPUT pulse width, or the interval between the OUTPUT pulses.

When the PULSE switch is in the DOUBLE position, the pulse width multivibrator is keyed at the beginning of the delay interval as well as at the end of the delay interval. See waveform F of Figure 3-1.

The signal from the timing board is then amplified and shaped by the output board and presented as an output.

3-3 BLOCK DIAGRAM

a. **Clock Multivibrator.** The clock multivibrator initiates each cycle of the output pulse train in all modes except ± EXT drive. The operation of the clock is dependent on the position of the FREQUENCY switch, and the voltage waveforms applied to the GATE INPUT. The two modes of operation for the clock are:

(1) Free-running. When the FREQUENCY switch is in any position except ± EXT, and the GATE switch is in the NORMAL position, the clock is a free-running emitter-coupled multivibrator. The FREQUENCY control selects a 3:1 frequency range between 10 Hz and 50 MHz, by selecting the value of the emitter coupling capacitor. The FINE (FREQ) control provides continuous adjustment over the selected frequency range and overlap into the two adjacent ranges. When the double pulse mode of operation is selected, the upper frequency limit is restricted to 25 MHz by substituting a fixed resistor for the FINE (FREQ) control on the top frequency range.

All other ranges operate normally in either single or double pulse modes.

(2) Gated Operation. The clock can be enabled or disabled by an externally applied voltage at the GATE INPUT connector between ±2 and ±15 V. With the GATE switch in the GATED ON position + voltage will gate the clock on, with the GATE switch in GATED OFF position - voltage will gate the clock off. These modes of operation produce pulse bursts synchronized with the gating waveform. When the GATE switch is in the NORMAL position, the clock free-runs at the frequency determined by the FREQUENCY range control and the FINE (FREQ) control.

(3) External Drive Operation. When the FREQUENCY control is in the EXT positions, the clock multivibrator is disabled. A Schmitt trigger circuit initiates a pulse for each input applied to the EXT TRIGGER INPUT connector, provided that the selection of the external drive polarity (FREQUENCY switch) and the position of the LEVEL

control are compatible with the polarity of the external drive signal. With the FREQUENCY switch in the EXT position, each time the SINGLE CYCLE button is depressed and released, a single output pulse should occur.

b. Trigger Multivibrator. The trigger multivibrator is a variable-width one-shot. The trigger multivibrator is keyed by the output of the clock multivibrator or by the external drive circuit. The output from the trigger multivibrator is a selectable positive or negative pulse, 1.5 V into 50 ohms, occurring at the beginning of each pulse train. The trigger amplitude may also be attenuated by a factor of X10 through a front panel selector switch.

c. Delay Multivibrator. The delay multivibrator is also a variable-width one-shot which is keyed by the output pulse from the clock multivibrator or the external drive circuit. The DELAY control selects the value of the common emitter capacitor, and the FINE (DELAY) control varies the charging time-constant of the common emitter capacitor.

The delay multivibrator has two outputs, each a positive-going, differentiated voltage spike. One output occurs at the beginning of the delay interval, and the other at the end of the delay interval. The output at the end of the delay interval keys the width multivibrator in all modes of operation. The output at the beginning of the delay interval keys the width multivibrator only in the DOUBLE PULSE mode of operation.

d. Width Multivibrator. The width multivibrator is a variable-width one-shot which determines the width of the output pulses. The width multivibrator is keyed by one or both of the outputs from the delay multivibrator, depending on whether or not DOUBLE PULSE operation has been selected. The period of the width multivibrator is effected by both the WIDTH control and the FINE (WIDTH) control. The WIDTH control selects the value of the emitter-coupling capacitor, and the FINE (WIDTH) control varies the charging time-constant of the emitter coupling capacitor.

e. Ac Coupled Flip-flop. Except for the offset circuitry, the output board's signal ground may be quite different from the timing board's. Hence, the timing signal is ac coupled to the output board through a transformer and capacitors. The differentiated signals are converted back to bistable signals via a flip-flop.

f. Inverter. By controlling which of the next amplifiers is energized during the astable period of the width multivibrator, the polarity switch determines if operation is in the inverted or normal mode of operation.

g. Amplifiers. The signal from the inverter is amplified, and this results in a lower output impedance and higher output current drive for the ramp generator.

h. Ramp Generator. Ramps are generated by charging and discharging a capacitor with current sources. The leading and trailing edge potentiometers control the value of the current and the RAMP switch determines the value of the capacitor allowing fine control and range selection respectively. The positive and negative clamps limit the excursions of the ramp generator with the negative clamp level determined by the amplitude potentiometer.

i. Emitter Follower. An emitter follower acts as a buffer from the ramp generator and provides increased drive to the output stage. The input to the emitter follower is now trapezoidal in shape.

j. Linear Amplifier. This stage amplifies the signal from the emitter follower and provides the output current.

k. Balun and POLARITY Switch. Here the POLARITY switch determines whether the pulse is negative or positive.

The purpose of the balun is to maintain the pulse until the supplies have moved an amount equal to the pulse amplitude.

l. Attenuator. The ATTENUATOR switch selects a straight through position (1:1), or a resistive attenuator network of 2:1, 4:1, 8:1, 16:1, 32:1, 64:1 or 128:1 between the output device and the OUTPUT connector. The output of the Model 135A is backmatched, thus at any attenuator position the source impedance is 50 ohms.

m. Offset. Offset is achieved by switching into the signal line the proper polarity current. The current enters after the attenuator and therefore is not attenuated.

3-4 CIRCUIT DESCRIPTION

a. Clock Multivibrator. The clock multivibrator is the internal repetition frequency generator. It determines the repetition frequency at which pulse trains are initiated in both the free-running mode, NORMAL position of the GATE switch, and the gated modes, +2 V GATED ON and -2 V GATED OFF positions of the GATE switch.

In the free-running mode the clock multivibrator has no inputs. It generates the repetition frequency interval in accordance with the value of the emitter-coupling capacitor selected by the FREQUENCY switch and the clamp voltage set by the FINE (FREQ) control. In the gated modes of operation, the saturating switch, Q18, in series with half of the multivibrator, stops or starts the clock, dependent upon the position of the GATE switch when an input of ±2 V to ±15 V is applied to the GATE INPUT connector. In the external drive mode of operation the internal clock is made inoperative by turning the saturating switch, Q18, and its drive circuitry, Q15 and Q16, off.

The clock is an astable emitter-coupled multivibrator made up of Q2 and Q3. Its free-running frequency is determined by the value of the emitter-coupling capacitor and the voltage switching amplitude of the two collectors. The FREQUENCY switch selects the value of the emitter-coupling capacitor. The FINE (FREQ) control varies the frequency over the selected range by controlling the collector clamp voltage through the emitter follower, Q1, and the collector clamp diodes, CR1 and CR2.

Q2 and Q3 are cross connected so that each base current path is through the collector load of the other. The two emitters are coupled by C5 and R123 and paralleled by C201 through C215 as selected by the FREQUENCY control. The result is that when either Q2 or Q3 conducts, the other is turned off and the transistor that is conducting pulls its emitter up. The voltage at the emitter of the other transistor decays towards ground with a time-constant set by the emitter-coupling capacitor and either R16 or R21. When the voltage at the emitter of the off transistor has decayed to one junction drop below its base voltage, the off transistor will turn on and (1) pull its emitter up, and (2) drop the base voltage of the other transistor. The emitter-coupling capacitor must then

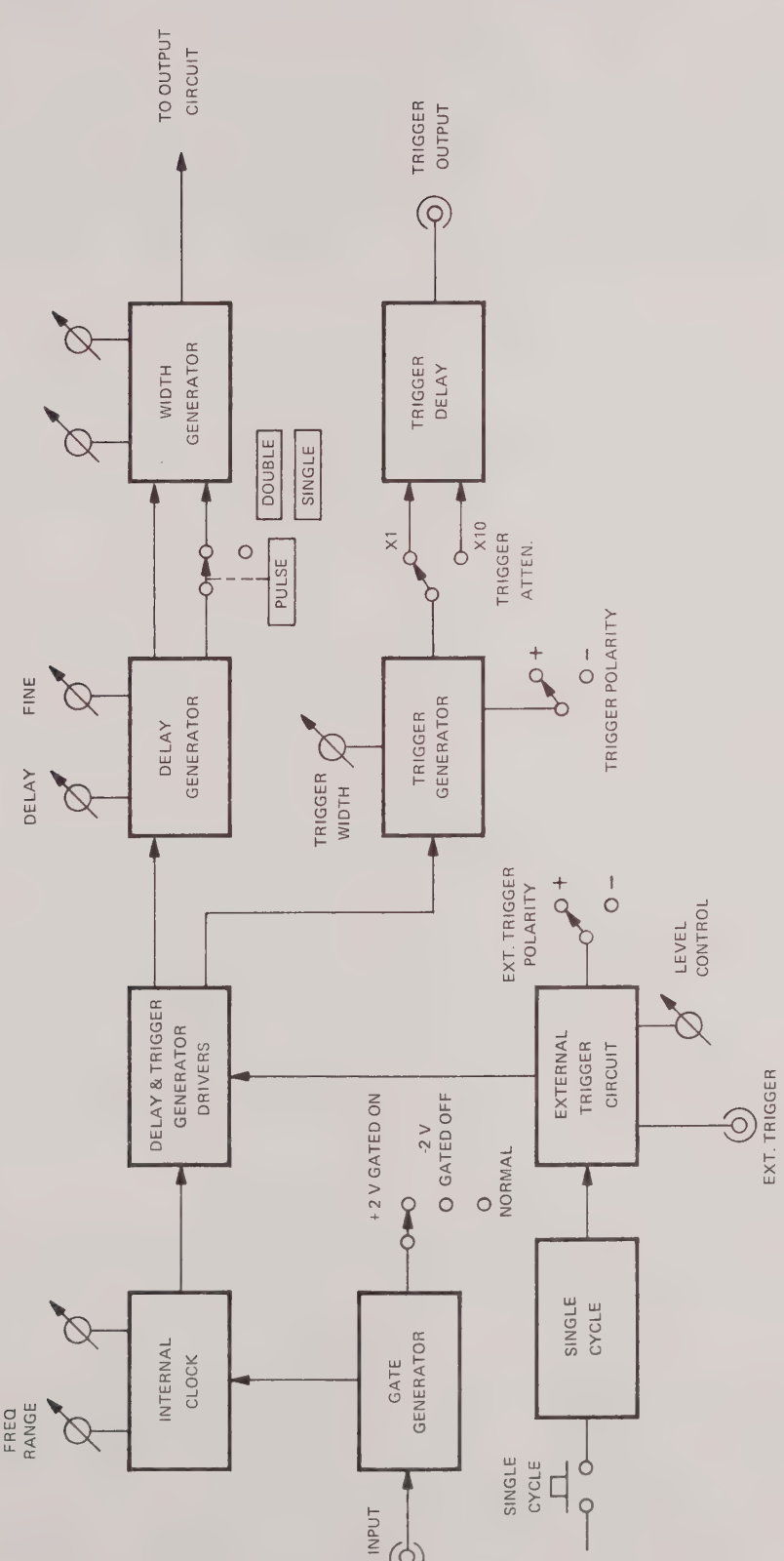


Figure 3-2 Timing Block Diagram

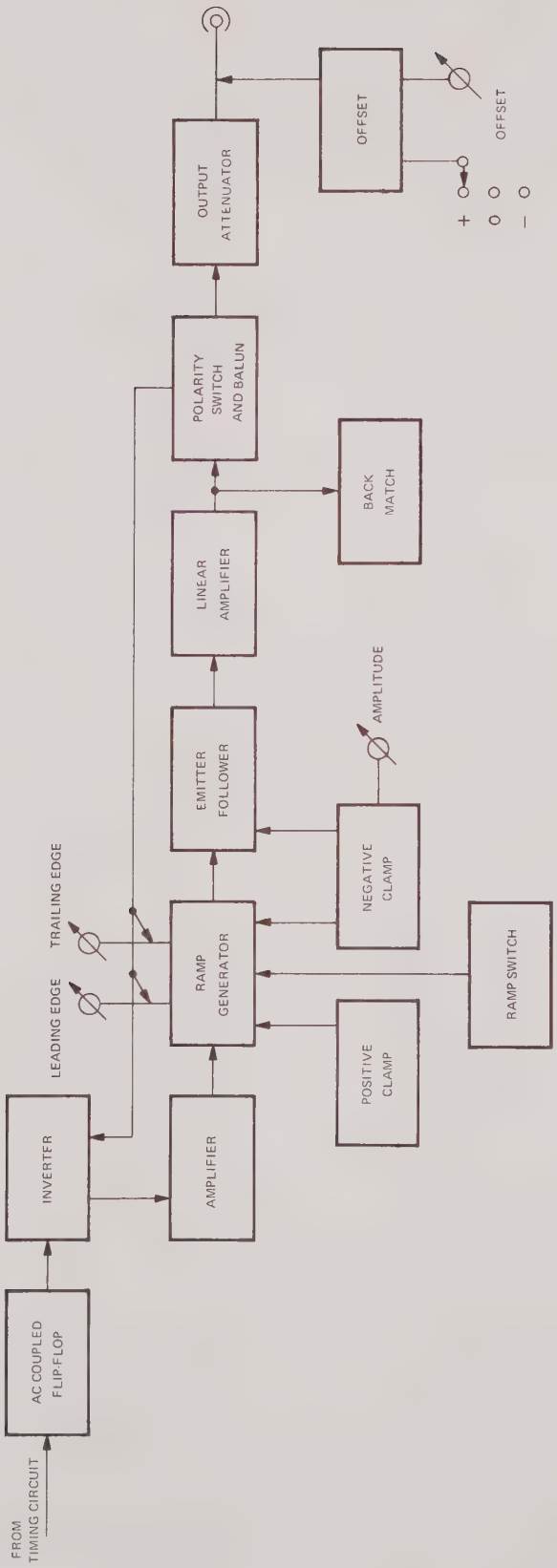


Figure 3-3 Output Block Diagram

discharge in the opposite direction through the other emitter resistor.

The FREQUENCY control influences the free-running frequency clock by selecting the value of the emitter-coupling capacitor, C201 through C215. The FINE (FREQ) control sets the clamp voltage that limits the negative excursion of the collectors. Since each base is referred to the other collector through a zener diode, the FINE (FREQ) control indirectly determines the voltage level at the base of the off transistor. It therefore determines how far the emitter-coupling capacitor must discharge before the off transistor will turn on.

The current-commutating pair, Q4 and Q5, alternately conduct the constant current provided by their common emitter resistor, R10. The voltage across R10 is set by either CR3 or CR4, depending on which state the clock multivibrator is in. Since CR3 and CR4 are a matched pair, R10 has a constant voltage across it and is therefore a constant current source. Q4 conducts all of the current provided by R10 during one half cycle of the clock, and Q5 conducts all of the current provided during the other half cycle of the clock.

The saturating switch, Q18, provides the ground return for the emitter resistor for half of the clock multivibrator. When the clock is in the free-running mode of operation and, the GATE switch is in the NORMAL position, Q18 is saturated holding the bottom of R21 at essentially ground potential. In either of the gating modes, GATED ON or GATED OFF, the saturated switch is turned on or turned off by the signal that is applied to the GATE INPUT.

When the GATE switch is in the NORMAL position, Q18 is held on by the positive current from resistor R52. When the GATE switch is in the -2 V GATED OFF position resistors R47 and R50 bias the Schmitt trigger circuit, Q15 and Q16, so that Q16 is on and providing base current to Q18, holding it on. When a -2 volt signal is applied to the GATE INPUT, transistor Q17 turns on. When Q17 is on, the junction of the zener diode CR18 and resistors R43, R44, R45, and R50 is pulled to about one diode drop below ground. This biases the Schmitt trigger circuit so that transistor Q15 is on and transistor Q16 is off. With Q16 off the source for base current to Q18 is removed and Q18 is turned off. With Q18 off the emitter current for one half the multivibrator is interrupted thus turning the internal clock off. The clock is held off for the duration of the gate signal.

When the GATE switch is in the +2 V GATED ON position resistor R47 is switched to ground, putting it in parallel with resistor R46 while one end of R50 is put at +15 V. When R47 is grounded, base resistor R51 is also grounded and thus provides base current for Q19, turning it on. Q19 is a saturating switch which puts one end of R45 at essentially -15 V. The quiescent state of the Schmitt trigger with this set of conditions has Q15 on and Q16 off. When Q16 is off, transistor Q18 is off, thus interrupting the emitter current for one side of the clock, holding it off. When a +2 volt signal is applied to the GATE INPUT, Q14 turns on, pulling the junction of the zener diode CR18 and resistors R43, R44, R45, and R50 to about one diode drop above ground. This biases the Schmitt trigger circuit so that transistor Q15 is turned off and Q16 is turned on. When Q16 goes on, Q18 is turned on, putting R21 at essentially ground. The clock then operates for the duration of the gating signal. In both gating modes the internal clock, during its on time, free-runs at the rate determined by its frequency controls.

In the EXT TRIGGER positions of the FREQUENCY control, the +15 V supply is removed from the GATE switch and the Schmitt trigger of the gating circuitry. Transistor Q18 is off, removing the emitter current from one side of the clock. Transistors Q8 and Q9 are both on, so clock transistor Q2 is on, and Q3 is off. This in turn establishes a biasing state on transistors Q4 and Q5, Q4 being off, and Q5 being on. The current into the collector load, under external drive conditions, from the collector of Q5 is cancelled out by the current required for R32. The collector loads of Q4 and Q5, whose waveforms switch the commutating pair Q6 and Q7, are the loads used by the external drive circuitry to initiate an output pulse train.

The external drive circuit consists of a Schmitt trigger, transistors Q20 and Q21, a variable voltage source, transistor Q22, and two selectable pairs of current commutating transistors connected in parallel. One pair is comprised of transistors Q10 and Q11, and the other pair is made up of Q12 and Q13. The appropriate pair, depending upon the EXT TRIGGER polarity switch position, is selected by applying -15 V to the junction of CR14 and CR15 or to the junction of CR16 and CR17. When the FREQUENCY switch is in the + EXT TRIGGER position, -15 V is applied to the junction of CR14 and CR15 thus enabling the transistor pair, Q10 and Q11. When the FREQUENCY switch is in the - EXT TRIGGER position, transistors Q12 and Q13 are enabled. In either EXT TRIGGER polarity the biasing of devices Q10 and Q11, or Q12 and Q13, is such that current is pulled out of resistor R23 making the voltage level across it negative and thus turning transistor Q7, of the pair Q6 and Q7, on.

Transistor Q22, the voltage source for the Schmitt trigger collector resistors, adjusts the triggering level of the Schmitt trigger, Q20 and Q21 with respect to the input drive voltage by means of the LEVEL control. The range of level control is from ±1 V to ±1.5 V. When the FREQUENCY switch is set at the + EXT TRIGGER position the LEVEL control is set so that transistor Q20 is on, thereby turning devices Q10 and Q7 on. When a positive signal is applied to the EXT TRIGGER INPUT transistor Q20 is turned off and Q21 comes on, which, in turn, turns transistors Q11 and Q6 on. When Q6 turns on, a pulse is initiated for the timing chain. When the triggering signal is removed, transistors Q20, Q10, and Q7 all return to the ON state.

When the FREQUENCY switch is in the - EXT TRIGGER position, the LEVEL control is set in the negative region, turning transistor Q21 on, and Q20 off. With Q21 on, transistor Q13 is on, thus turning transistor Q7 on. When a negative signal is applied to the EXT TRIGGER INPUT, transistor Q20 is turned on, Q21 turns off, and Q12 turns on, which turns transistor Q6 on, and Q7 off. When the negative drive signal is removed the Schmitt trigger returns to its previous condition of Q21 on, and Q20 off.

When the FREQUENCY switch is in either one of the external drive polarities the Model 135 may be single cycled by pushing and releasing the SINGLE CYCLE button. The SINGLE CYCLE button is connected to the bases of both transistors Q23 and Q24. By pushing and releasing the SINGLE CYCLE button transistors Q23 and Q24 provide both a positive and negative spike to the base of the voltage source, Q22. One of the spikes from the single cycle circuit will cause the Schmitt trigger circuit to switch states, initiating a pulse in the timing chain.

When the FREQUENCY switch is in any position other than the two external drive positions, both driving pairs, Q10 and

Q11, or Q12 and Q13, are inoperative because their emitter resistors have one end opened.

The commutating pair, Q6 and Q7, are switched by the waveforms across R23 and R24. The waveforms across these resistors can occur from either transistors Q4 and Q5, determined by the internal clock, or from the appropriate external drive pair. Resistor R5 provides a constant current of about 30 mA from the +15 V supply. Q6 conducts the current from R5 on alternate half cycles of the clock multivibrator or from the external drive signal. The collector waveform of Q6 is differentiated by the inductor, L1, producing a sharp positive voltage spike when Q6 goes into conduction, and a sharp negative spike when Q6 turns off. The positive voltage spike is coupled through CR11 to key the delay multivibrator, and through CR29 to key the trigger multivibrator.

b. Trigger Generator. The trigger generator provides a ±1.5 V output pulse at the TRIGGER OUTPUT connector at the beginning of the pulse train in all modes of operation. The trigger multivibrator is a variable-width emitter-coupled one-shot, made up of Q33 and Q34. The current mode pair, Q35 and Q36, couples the trigger pulse to the TRIGGER OUTPUT connector through a 18 ns delay line. The purpose of the delay line is to make the delay between the leading edge of the trigger pulse and the leading edge of the output pulse less than 10 ns when the minimum delay is selected.

The trigger multivibrator is keyed at the beginning of the delay interval in all modes of operation by the output of transistor Q6. The trigger pulse-width is variable by the front-panel mounted TRIGGER WIDTH control.

The voltages at the bases of Q33 and Q34 are set in the quiescent condition by a pair of matched zener diodes, CR48 and CR50. Current from the -15 V supply through R47 forward biases the clamp diode, CR49. This sets the reference for CR48 at one junction drop below ground. Conduction of Q33 forward biases CR52 and CR53, setting the voltage reference for CR50 at two junction drops above ground. Since the zeners, CR48 and CR50, have the same voltage drops, the voltage at the base of Q34 is three junction drops more positive than the voltage at the base of Q33. In the quiescent condition Q33 conducts the current provided through R206, R219 and R109 from the +15 V supply. Q33 also conducts the current provided through R110 and CR47, holding the emitter of Q34 more negative than its base. Q34 does not conduct in the quiescent condition.

The positive voltage spike from the collector of Q6 at the beginning of the delay interval is coupled through CR29 and CR48 to the base of Q33, turning off Q33. The resulting negative-going waveform at the collector of Q33 is coupled through CR50, to the base of Q34, turning on Q34. When Q34 turns on, the negative-going step at the emitter of Q34, coupled through C21, pulls the emitter of Q33 negative. Q33 will remain turned off until C21 charges through R109, R206 and R219, far enough for the emitter of Q33 to go one junction drop more positive than its base. When C21 has charged enough to forward bias the base-emitter junction of Q33, Q33 goes back into conduction, the collector of Q33 turns off Q34, and the multivibrator regenerates Q33 into its quiescent condition.

Q35 and Q36 make up a current-commutating output pair for the trigger multivibrator. In the quiescent condition Q36 conducts the current provided through the common emitter resistor, R112, from the +15 V supply, and Q35 is turned off. During the astable period of the trigger multivibrator, Q35 conducts the common emitter current, and Q36 is turned off. The collector waveforms of Q35 and Q36 are the trigger output waveforms. When the TRIGGER POLARITY switch is in the positive position the output current from Q35 provides the positive trigger output. If the TRIGGER POLARITY switch is in the negative position the collector current of Q35 flows into the 51 ohm terminating resistor R222. The zener diode CR55 and the diode CR54 provide a sink for the collector current of Q35 if its output is working into an open circuit. CR54 will clamp the collector of Q35 at approximately 4 V.

When Q36 is on its collector current flows into the resistor combination of R120 and R121, plus the trigger load. Resistor R120 is selected to give a trigger baseline of zero volts when the trigger load is 50 ohms. This resistor, R120, is selected so that its combination with R121 requires the correct amount of current to cancel the common emitter current, establishing the collector at a ground level. When Q36 is turned off, the resistor combinations of the trigger 50-ohm load and the R120, R121 combination form a voltage divider between ground and -15 V. The negative trigger pulse will be clamped at approximately -4 V by the zener diode, CR57 and diode CR56, if the negative trigger output is operated into a high impedance load.

Both polarities may be attenuated by a factor of ten by means of the ATTENUATOR switch S204.

c. Delay Multivibrator. The delay multivibrator is a variable width emitter-coupled one-shot made up of Q25 and Q26. Q27 and Q28 are a current-commutating pair which provide the outputs from the delay circuit.

The delay multivibrator is keyed by the differentiated output from the clock multivibrator. The front-panel DELAY control selects the value of the emitter-coupling capacitor, C216 through C225, and the FINE (DELAY) control determines the charge time-constant of the emitter-coupling capacitor. The output of the delay circuit keys the width multivibrator, and determines the time interval between the trigger output and the pulse output. In the double pulse mode, the delay circuit keys the width multivibrator at the beginning of the delay interval and at the end of the delay interval.

In the quiescent condition, Q25 is conducting and Q26 is turned off. The matched pair of zener diodes, CR12 and CR32, set the voltages at the bases of Q25 and Q26. Current through R26 from the -15 V supply forward biases the clamp diode, CR13, and sets the reference for CR12 at one junction drop below ground. Collector current from Q25 forward biases CR45 and CR46, setting the reference for CR32 at two junction drops above ground. The quiescent voltage at the base of Q26 is three junction drops more positive than the voltage at the base of Q25. Q25 conducts the current provided through R201, R220 and R79 from the +15 V supply. Q25 also conducts the current provided through R80 and CR30 from the +15 V supply holding the emitter of Q26 more negative than its base.

The sharp positive voltage spike from the collector of Q6 is coupled through CR11 and CR12 to the base of Q25, turning Q25 off. The resulting negative-going-waveform at the collector of Q25, coupled through the emitter-coupling capacitor, holds Q25 off for a period determined by the charging time-constant of the emitter-coupling capacitor. After the emitter coupling capacitor has charged through

R79, R201 and R220 far enough for the emitter of Q25 to go one junction drop more positive than its base, Q25 turns back on. The collector waveform of Q25 turns off Q26, and the delay multivibrator regenerates into its quiescent condition.

Q27 and Q28 make up a current-commutating output pair for the delay multivibrator. In the quiescent condition, Q28 conducts the current provided through the common emitter resistor, R82, from the +15 V supply, and Q29 is turned off. During the astable period of the delay multivibrator, Q27 conducts the common emitter current, and Q28 is turned off. L3 in the collector circuit of Q27 differentiates the positive-going collector waveform of Q27 and produces a sharp positive voltage spike at the beginning of the delay interval. L2 in the collector circuit of Q28 differentiates the collector spike at the end of the delay interval. The positive voltage spike from L2 at the end of the delay interval is coupled through CR38 to the width multivibrator in all modes of operation. The positive voltage spike from L3 at the beginning of the delay interval is coupled through CR42 and CR43 only if biasing is applied to CR42 and CR43 by the PULSE mode switch in the DOUBLE position.

d. Width Multivibrator. The width multivibrator is a variable width-emitter-coupled one-shot made up of Q29 and Q30. Q31 and Q32 are a current-commutating pair which provide the outputs from the width multivibrator.

The width multivibrator is keyed by the differentiated output of the delay multivibrator at the end of the delay interval in all modes of operation. The width multivibrator is keyed at both the beginning and the end of the delay interval in the double pulse mode of operation. The front-panel WIDTH control selects the value of the emitter coupling capacitor. C226 through C235, and the FINE (WIDTH) control determines the charging time-constant of the emitter-coupling capacitor. The outputs of the width multivibrator drives the input of the output board.

In the quiescent condition, Q29 is conducting and Q30 is turned off. The matched pair of zener diodes, CR34 and CR35, set the voltages at the bases of Q29 and Q30. Current through R107 from the -15 V supply forward biases the clamp diode, CR44, and sets the reference for CR34 at one junction drop below ground. Collector current fromQ29 forward biases CR39 and CR40, setting the reference for CR35 at two junction drops above ground. The quiescent voltage at the base of Q30 is three junction drops more positive than the voltage at the base of Q29. Q29 conducts the current provided through R85, R204 and R221 from the +15 V supply. Q29 also conducts the current provided through R86 and CR31 from the +15 V supply, holding the emitter of Q30 more negative than its base.

The sharp positive voltage spikes from the delay multivibrator output stage are coupled through CR38 to the base of Q29, turning off Q29. The resulting negative-going waveform at the collector of Q29 coupled through CR35 turns on Q30. When Q30 turns on, the negative-going waveform at the emitter of Q30, coupled through the emitter-coupling capacitor, holds Q29 off for a period determined by the charging time-constant of the emitter-coupling capacitor. After the emitter coupling capacitor has charged through R85, and R204 and R221 far enough for the emitter of Q29 to go one junction drop more positive than its base, Q29 turns back on, the collector waveform of Q29 turns off Q30, and the width multivibrator regenerates into its quiescent condition.

Q31 and Q32 make up a current-commutating output pair for the width multivibrator. In the quiescent condition, Q32 conducts the current provided through the common emitter resistor, R88, from the +15 V supply, and Q31 is turned off. During the astable period of the width multivibrator, Q31 conducts the common emitter current and Q32 is turned off. The outputs from Q31 and Q32 drive the transformer input of the output board.

e. Ac Coupled Flip-flop. Transformer T1 provides the ac coupling from the timing board to the output board. Transistors Q1 and Q2 comprise the flip-flop that is triggered by the differentiated timing signals. CR1 and CR2 are matched zeners that provide cross coupling. For example: assume that Q1 is on and Q2 is off. With Q2 off the only current through R9 is a small amount of CR1 bias current. R8 has all of the emitter current passing through it; hence the base of Q2 is more positive than Q1. R3 is picked so that Q2 is indeed off. A positive-going transition and a negative-going transition will be translated to the bases of Q1 and Q2 respectively as differentiated spikes and will change the state of the flip-flop.

f. Inverter. The inverter determines whether the pulse output stage will conduct during the astable state of the width multivibrator or whether the output stage will conduct at all times except during the astable period of the width multivibrator. By selecting the output signals of the flip-flop for the appropriate inputs of the next amplifier, the inverter accomplishes this end. Connected to each collector of the flip-flop are two transistors, forming two current mode amplifiers. The collectors of these amplifiers are cross coupled to achieve the inversion. The polarity switch selects which amplifier is energized. In the normal modes Q3 and Q4 are enabled while the emitters of Q5 and Q6 are biased to disable them. In the inverted modes Q5 and Q6 are energized while Q3 and Q4 are disabled.

g. Amplifiers. Q7 and Q8 comprise and emitter coupled pair operating in a non-saturating mode. The differential base signals are such that either one or the other conducts all the emitter current. The signal from this pair drives the ramp generator.

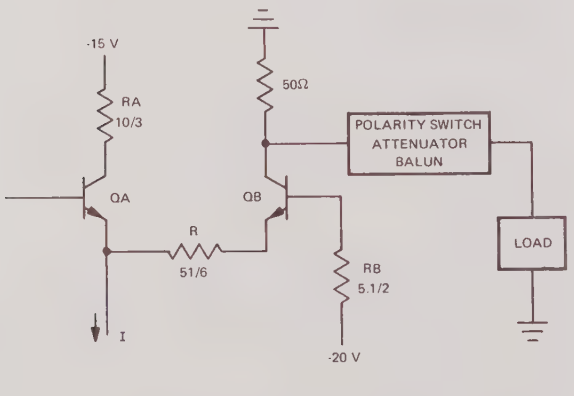
h. Ramp Generator. Ramps are initiated by switching a constant current in or out of a fixed capacitor. The output of the previous amplifier feeds a four-transistor current switch, Q9, Q10, Q11 and Q12, which switch the ramp current. Q10 and Q12 switch the currents which charge and discharge the ramp capacitor. Q10 and Q12 are each part of emitter coupled pairs that are coupled via matched zener diodes. The output of the previous amplifiers is bistable and complementary so if Q10 is on ($V_{B10}<V_{B9}$)Q12 is off ($V_{B12}<V_{B11}$) and vice versa. Since $dV/dt = I/c$ the value of the current determines the slope of the ramp for fixed C. This current is changed by varying the current sources via the front panel controls to the emitter coupled pairs. These controls are the leading and trailing edge pots. Since the leading edge current in the negative normal mode is the trailing edge current in the negative inverted mode, switching must be provided so that the leading edge pot on the front panel functions properly in both the normal and the inverted modes of operation. The switching is accomplished through the POLARITY switch.

With either current switch Q10 or Q12 on, a capacitor would charge positively or negatively with respect to -20V at a constant slope until the level was sufficient to saturate the current switches. Clamps are provided to prevent saturation.

When Q10 is on, the timing capacitor will charge positively until diode CR8 turns on and clamps the positive excursion. Q22 provides the low impedance sink which must absorb the charging current and sets the level of the positive clamp. When Q12 is on, the timing capacitor will charge negatively with respect to -20 V until CR7 turns on and clamps the negative excursion. Q19, Q20, and Q21 comprise the adjustable negative clamp supply, which controls the outputpulse current amplitude. The front panel amplitude potentiometer controls the voltage at the base of Q20 and hence controls the emitter voltage of Q21. For different ramp ranges, different capacitors are switched in.

i. Emitter Follower. An emitter follower acts as a buffer from the ramp generator and provides increased drive to the output stage. The input to the emitter follower is now trapezoidal in shape. This waveform is translated to the emitter of Q23, but the negative excursions are clamped to the negative clamp level by CR6. Since the negative excursion determines the pulse amplitude the second negative clamp removes any pulse top distortions occuring at the ramp generator that are less than a diode drop in amplitude. Q43 is a current source which presents a high impedance to the output of the emitter follower and provides drive current to the next stage, particularly if Q23 is forced "off" suddenly. Inductors L6 and L5 help isolate the parasitics present at the collector of Q43 from the emitter follower-linear amplifier interface.

j. Linear Amplifier. This is the output amplifier that provides the output current. One can model the amplifier as shown below.



Output Amplifier Model

The clamp levels are such that in the output "off" state, the input to A is greater than -20V, and in the output "on" state, the input is less than -21V. QA acts as an emitter follower whose emitter current is I when the input is in the "off" state. The emitter of QA is high enough so that QB is off and no current flows through R. As the emitter of QA goes negative a portion of I is switched from QA to QB. The maximum voltage across R limits the output current and is determined by the negative clamp level. In the actual circuit, Q18 is the current source, Q29 and Q30 comprise QB, and Q24, 25, and 26 comprise QA. Resistors R97 through R100 help insure current sharing in Q24, 25, and 26. C27, R105 and R106 present a lower emitter impedance for a portion of time, hence, increasing the output current for that portion of time. The output current now goes into a 50-ohm resistive back match and into the POLARITY switch.

k. Balun and POLARITY switch. Here the POLARITY switch determines whether the pulse is negative or positive. The POLARITY switch connects the output cable shield to V_O, the floating signal reference ground of the output board, and the output cable's center conductor to the output pair collectors in the negative modes; and the cable shield to output pair collectors and the center conductor to V_O in the positive modes. Note that in the positive modes V_O and the floating supplies move with respect to chassis ground during the pulse.

The purpose of the balun is to maintain the pulse until the supplies have moved an amount equal to the pulse amplitude. The resistors across the POLARITY switch help to eliminate disturbances caused by the balun and ground parasitics being excited. The balun is comprised of the components in T2.

l. Offset. Offset is achieved by switching into the signal line the proper polarity current. The current enters after the attenuator and therefore is not attenuated. The current has a maximum value of 200 mA in either direction and a minimum value of leakage in the tens of microamps. Q40 and Q41 are the current sources and Q39 and Q42 their respective drivers.

The OFFSET switch presents the appropriate signal at the driver bases. R113 and R119 help insure that the emitter base junctions are off during the full ccw position of the OFFSET pot. Q38 has a voltage gain of 1 and acts as a voltage source for both current source drivers. It's input is controlled by the front panel potentiometer. CR19 helps to provide thermal stability. The drivers and their current sources are of opposite "sexes" which aid in temperature stability also.

SECTION 4
MAINTENANCE

4-1 GENERAL INFORMATION

This section of the manual gives maintenance notes and alignment procedures for the E-H Model 135A. The instrument requires a minimum amount of maintenance; however, normal aging of electronic components may eventually cause abnormal operation. Use of the following procedures should forestall many minor malfunctions, or permit their detection before a major repair is required.

4-2 PREVENTIVE MAINTENANCE

a. Cleaning and Visual Inspection. A regular program of inspection and maintenance is recommended to minimize down-time. The operating environment and amount of usage will dictate how often the instrument should be cleaned; in the absence of more stringent conditions, inspection every four to six months is recommended. Check the instrument in the following manner:

(1) Disconnect the power cord. Inspect the exterior of the instrument for broken knobs, switches, or connectors.

(2) Remove the top and bottom covers using the disassembly procedure in Subsection 4-4. If the internal surfaces and components have an excessive amount of dust deposited on them, use a low-pressure stream of air and a soft brush to remove the foreign material.

CAUTION

Do not clean the printed circuit boards with solvents, since damage to the circuits may result.

(3) Check the physical integrity of components and wiring. Look for evidence of loose connections, broken terminals, leakage of insulation compounds, and heat damage. In most cases, the source of a visually detected trouble is easily located. In the case of heat damage however, care should be taken to locate the original cause of the overheating before the instrument is put back in service.

b. Voltage Checks. The following voltage checks will aid in locating possible trouble spots. The dc measurements can be made with a volt-ohm meter or any high impedance voltage meter; the ac measurements can be made with any real time oscilloscope with sensitivity in excess of 10 mV. At 115 Vac the dc voltage between the chassis ground and the following points on the regulator board should be within 50 mV of the nominal value and have ripple of less than 10 mV. The POLARITY switch should be in the NEGATIVE NORMAL position. The supplies at b and h should have their ripple measured between pin A.

Terminal	Voltage
W	+20 V
Y	+15 V
M	-20 V
H	-20 V
G	-35 V
Z	-15 V

4-3 PERFORMANCE VERIFICATION PROCEDURE

The following procedure serves as both a "covers on" receiving inspection and a check of the instrument's specifications. In the former sense, this check should be performed as soon as possible after receipt of the instrument. In the latter sense, the procedure can be used to verify the effectiveness of repairs or alignment.

a. Recommended Test Equipment. The following is a list of the test equipment recommended for verifying proper operation of the E-H Model 135A Pulse Generator.

(1) Oscilloscope. A fast rise-time oscilloscope having an effective passband sufficient for accurate observation of 2 ns rise-time pulses. Two vertical channels plus dc offset capability is also necessary to make the correct measurements.

NOTE

$T^2_{observed} = T^2_{generator} + T^2_{scope}$.

(2) A general purpose oscilloscope with dc to 25 MHz passband.

(3) A digital voltmeter.

(4) A pulse generator having a repetition rate to 50 MHz and a variable output to at least 2 V into 50 ohms.

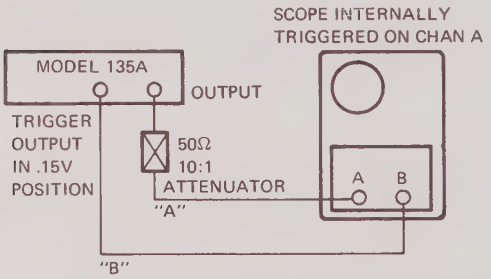
(5) Several lengths of good quality 50-ohm coaxial cable and a high-quality 10:1 rf attenuator.

CAUTION

The full unattenuated output of the Model 135A is capable of permanently damaging the input of a sampling oscilloscope. In the X1 and X3 attenuator positions the Model 135A can deliver output pulses greater than 1 V. When using these positions be sure there is enough attenuation in the signal line to protect the scope. The trigger output of 2 V can also damage the oscilloscope's trigger input.

b. Initial Set-up. The function of the front panel controls and connectors is described in an earlier section. During the checking of any particular function, controls for the other functions may be varied as necessary to maintain a meaningful presentation on the oscilloscope. Initial set-up of the front panel controls should be as follows:

PULSE MODE	SINGLE
POWER	OFF
FREQUENCY	1 MHz/3 MHz
FINE	ccw
DELAY	10/50 ns
FINE	ccw
WIDTH	200/1 μs
FINE	ccw
OFFSET	OFF and ccw
POLARITY	NEGATIVE NORMAL
TRIGGER	+0.2 V
RAMP SWITCH	0.4/1 ns/1 V at X1 edges - ccw
LEADING EDGE	ccw
TRAILING EDGE	ccw
ATTENUATOR	X8
AMPLITUDE	ccw
GATE	NORMAL



EH-L0412

Figure 4-1 Sampling Oscilloscope Test Set-up

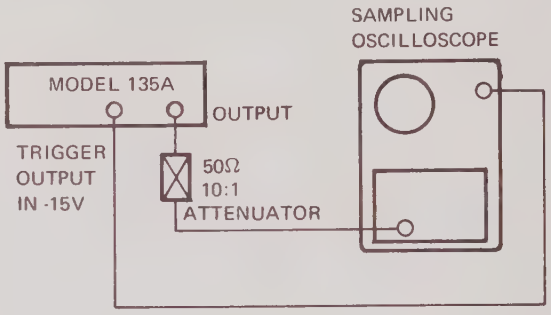
Connect the Model 135A's TRIGGER OUT to the TRIGGER INPUT of the high pass band oscilloscope to externally trigger the scope. Terminate the output of the Model 135A in 50 ohms and connect it to the input of the oscilloscope. Note that a sampling oscilloscope usually is terminated in 50 ohms.

Trigger the oscilloscope externally with the positive trigger, set the vertical sensitivity to display a 300 mV pulse and set the time base to display a 1 MHz pulse rate. (e.g., external positive, 100 mV/cm, and 1 μs/cm.) Turn the POWER ON and adjust the trigger point on the oscilloscope if necessary. A pulse train should now appear on the oscilloscope.

c. Repetition Rate Check. Requirement: internal clock frequency continuously variable from less than 10 Hz to more than 50 MHz. Check to see that the FINE FREQUENCY control operates smoothly, especially at the higher ranges and that there is overlap from each range into its next higher range.

The DELAY switch can be fixed at its lowest range and the WIDTH switch should be adjusted with the FREQUENCY switch so that the pulses are visible. Note that a real time oscilloscope should be used for lower frequencies. Alternatively a frequency counter can be used.

d. Width and Delay Check. Requirement: both continuously variable from less than 10 ns to greater than 50 ms. The check here is similar to the frequency check with the same set-up used. Check to see that the FINE controls operate smoothly and that there is overlap from one range into its neighboring ranges. Pulse width is measured at 50% amplitude. Pulse delay is measured from the 50% point on the leading edge of the trigger to the 50% point on the leading edge of the output.



EH-L0413

Figure 4-2 Delay Check Test Set-up

When measuring widths and delays be sure that the RAMP switch is in its minimum range and that the FINE controls are full ccw. It will be necessary to adjust the frequency so that the period is greater than the sum of width + delay. A general purpose oscilloscope should be used at long delays and widths. For short delays the cable length of the trigger cable and the output cables should be of the same length in time.

e. Amplitude and Attenuator Check. Requirement: ± 30 mV to ± 10V into 50 ohms. Set up the Model 135A for a pulse width of 1 μs and a frequency of 100 Hz. The POLARITY switch should be changed to the POSITIVE NORMAL position. Remember the earlier caution in using

X1, X2, and X4 attenuator output positions and the necessity of padding in the signal line. The input level to most sampling oscilloscopes should not exceed 1 V requiring that only those positions of the attenuator that give 1 V or less output (zero offset) should be used. The pulse amplitude shoudl be at least +10 V and the amplitude shoudl move below +3 V smoothly as the amplitude pot is turned. Switch the POLARITY switch to the NEGATIVE NORMAL position and observe the excursions from -10 V to less than -3 V. Switch the attenuator to X2; the amplitude excursions should exceed the numbers on the front panel below X2, 1.5 to 5 V.

The procedure for checking all other attenuator settings is the same as that outlined above.

f. Polarity Switch Check. Requirements: four distinct modes of pulse output. Set up the Model 135A for a 1 μs width pulse and a 100 Hz frequency with the amplitude set full cw and the attenuator set at X8. With the POLARITY switch in the POSITIVE NORMAL position check to see that during the 1 μs pulse the output is from a 0 V baseline to a 1.25 V pulse top. In the NEGATIVE NORMAL position it shoudl go from a 0 V baseline to a -1.25 V pulse, in the NEGATIVE INVERTED position from a -1.25 V to 0 V, and in the POSITIVE INVERTED position from +1.25 V to 0 V.

g. Offset Check. Requirements: a continuous change from 0 V to ±5 V. Switch the GATE switch to +2 V GATED

ON and terminate the output in 50 ohms. Across the 50-ohm termination measure the offset voltage with a VOM or equivalent. The offset voltage at the output connector should be less than 7 mV with the offset pot in any position. With the OFFSET switch in either the + or - position the offset should go beyond ± 5 V as the pot is turned. One can also observe on the oscilloscope the baseline movement. Use a X10 pad when using a sampling oscilloscope.

h. Ramp Time Checks. Requirement: a continuous variation of rise and fall times from 3 ns to 8 ms.

Turn the AMPLITUDE pot full cw, the ATTENUATOR to X8, and the polarity switch to NEGATIVE NORMAL. Adjust the WIDTH to 50 ns at a frequency of 1 MHz. The RAMP switch should be turned to the 0.4/1 ns/ V position with its fine control pots, the leading and trailing edge pots, turned full ccw. Transition time is observed between the 10 and 90% amplitude points.

The rise and fall times in this position should be less than 3 ns. Keep in mind the aforementioned scope limitations in measuring transitions. Switch through the various polarities together with the offset to insure that the transition times are adequate for all combinations. Turn the fine pots cw to observe a smooth changing of the transition times. Change the ranges to ensure overlaping. Note that the width of the output pulse should be wide enough so that the ramps can be observed. With a large ramp setting and narrow width no output pulse will result. For this function the nomenclature on the front panel indicates the nominal ramp excursions.

i. Output Pulse Shape. Requirements: the peak-to-peak amplitude departures from a flat pulse top must be less than 5% of pulse amplitude. The peak-to-peak amplitude departures from a flat baseline must also be less than 5% of pulse amplitude. Monotonic (constant sign of the slope) disturbances along the edges are not considered part of peak-to-peak.

CAUTION

Many oscilloscopes with subnanosecond rise-time capability contribute a significant amount of overshoot and ringing when displaying a fast rise-time waveform. Effective evaluation of the output pulse waveform from the Model 135A requires use of an oscilloscope that is reasonably free from these vertical amplifier disturbances. Also, pay particular attention to the signal handling coaxial between the output connector and the input to the oscilloscope.

Peak-to-peak measurements should be made at various widths, polarities, offset and attenuator positions.

j. Trigger Output Waveform. Requirement: trigger output pulse must be a selectable positive or negative pulse with amplitudes selectable to greater than ±1.5 V or greater than ±0.15 V. Trigger width should be adjustable from less than 10 ns to greater than 50 ns. Internally trigger the oscilloscope to observe this.

k. External Trigger. With the FREQUENCY switch in either the + or - position, a minimum 1 V signal of the selected polarity should be fed into the EXT TRIGGER connector to externally drive the Model 135A from 0 to 50 MHz. The frequency of the output train follows that of the external source. The delay and width controls set their respective parameters. With an external pulse generator drive the Model 135A from 0 to 50 MHz in both polarities. The front panel LEVEL pot controls the triggering threshold. The external trigger width should be greater than 5 ns. Here again pulse width and delay have to be adjusted to allow proper pulse presentation on the oscilloscope.

l. Single Cycle Check. With the FREQUENCY switch in one of the external drive positions, pushing and releasing the SINGLE CYCLE button should cause a pulse to occur. Note that with a sampling oscilloscope each single cycle causes one sample to be taken.

m. Gate Check. Requirement: the output pulse train must start and stop in accordance with the gate input signal and the position of the gate mode switch. In the NORMAL position the Model 135A puts out a continuous pulse train as set by the front panel controls. In the -2 V GATED OFF mode the pulse train operates continuously when the voltage at the GATE INPUT equals zero. When the GATE INPUT goes to any level between -2 V and -15 V the pulse train is stopped. In the +2 V GATED ON mode, when the gate input goes from 0 V to anywhere between +2 and +15 V the pulse train is started. Set the internal FREQUENCY of the Model 135A to a high frequency. Pick a width for the gate drive signal to be several periods of the internal frequency. (e.g., 10 MHz internal clock and 5 μs gate width). In both modes after adjusting the gate input signal there should be clean pulse bursts with no am or fm.

n. Double-pulse Check. Requirements: in the double pulse mode two identical pulses are generated, one at the beginning of the delay interval, and the other at the end of the same interval. The delay interval is controlled by the front panel delay controls. Minimum spacing between pulses is 50% of the width range minimum or 15 ns, whichever is greater.

The double pulse mode, if operated within the above constraints, should work smoothly.

4-4 CALIBRATION PROCEDURE

a. General. The recalibration procedure should be performed following component replacement and at any time when failure to meet specifications is not traceable to component failure. Calibration should not be attempted on a routine basis; routine maintenance is given in Subsection 4-2.

b. Disassembly Procedure.

WARNING

DANGEROUS VOLTAGES ARE PRESENT ON EXPOSED TERMINALS IN THE AC POWER DISTRIBUTION WHEN THE INSTRUMENT IS PLUGGED IN. THESE VOLTAGES ARE ALSO PRESENT IN THE POWER SUPPLY WHEN THE INSTRUMENT IS ENERGIZED.

c. Recommended Test Equipment. The same equipment as used in the verification procedure may be used in the calibration procedure.

d. Initial Set-up. Set the Model 135A as follows: pulse, SINGLE; polarity, POSITIVE NORMAL; offset, OFF; gate, NORMAL; frequency, 30/100 kHz-cw; ramp range, minimum; amplitude, maximum; attenuator, X1, width

1/5 μs-ccw, delay a value sufficient to display the entire pulse.

e. Regulated Supplies. There are two adjustments in the regulator board, one for the -35 V floating supply and the other for the +20,V non-floating supply. Measure the -35 V supply between pins G and J on the regulator board with an accurate VOM. Adjust R37 on the regulator board to get within 50 mV of -35 V. Measure the -20 V floating supply between pins H and J on the regulator board. It should read within 50 mV of -20 V. The valve of the resistor in parallel with R48 should be decreased to make the -20 V supply more negative and it should be increased to make the -20 V supply less negative.

Measure the +20 V supply between pins Y and W on the regulator board. Adjust R6 to bring the +20 V supply to within 50 mV of +20 V. Measure the +15 V supply between pins X and Y on the regulator board. The reading should be within 50 mV of ±15 V.

f. Frequency Ranging. Make sure that the frequency pot on the front panel is turned full cw and is in the 30/10 mHz range. Adjust R1 on the timing board so that the maximum frequency is 10.5 mHz. Turn the FINE FREQUENCY control ccw to see that the minimum frequency for this range is less than 30 kHz.

g. Amplitude Calibration. Set up the conditions as in 4-4 d. Turn the FINE FREQUENCY control ccw and display one full scale pulse on the oscilloscope. Measure the voltage across R48 with a multimeter at the collector of Q18. Adjust R44 on the output board so that the R48 current is 530 mA. Adjust R42 for a +10.1 V amplitude. Switch the POLARITY TO NEGATIVE INVERTED. Examine the peak-to-peak at the fourth corner of the pulse at a width from 200 ns to 5 ms. Adjust R44 until a decrease in the current of R48 starts to increase the peak-to-peak distortion at the fourth corner.

Back R44 off slightly and check the POSITIVE NORMAL amplitude at 1 μs width to see that it is still greater than +10 V. If not start at a higher R44 current and a higher amplitude on the R42 adjustment. This current should not exceed 570 mA in the normal mode.

SECTION 5
PARTS LIST

5-1. ORDERING INFORMATION

Replacement parts may be ordered through an E-H Representative or directly from the factory. To be certain of receiving the proper parts, always include the following information with the order:

a. Model number and serial number of the instrument on which the parts will be installed.

b. Circuit reference number and subassembly name, if applicable, for which the part is intended. If the part does not have a circuit reference, the description from the parts list should be used.

c. E-H part number.

The warranty is given on page ii of this manual, opposite the Table of Contents. For factory repair, contact the Customer Service Department of E-H Research Laboratories, Inc., at the address given on the title page of this manual. Include the following information:

a. Model number and serial number of the instrument on which the work is to be performed.

b. Details concerning the nature of the malfunction; or, type of repair desired.

5-2. HOW TO USE THIS PARTS LIST

The parts list is divided into subsections corresponding to the physical subsections of the instrument (printed circuit boards, chassis and subassemblies, miscellaneous hardware). Component locations can be determined from the schematic diagrams; each component appears only once in the parts list. At the beginning of each subsection are listed part numbers for any complete subassemblies in that category that are available as replacement parts. These subassemblies may include individually-listed components; care should be taken to locate malfunctions to the lowest possible level of replacement part and thus avoid the time and cost involved in "over-repair".

In the component descriptions, capacitor dielectrics are abbreviated as follows: polyethylene (poly.), ceramic (cer.), printed circuit (P.C.), electrolytic (elect.) and tantalum (tant.). Resistor and potentiometer values are given in ohms; the symbol for "ohm" (Ω) has been omitted. If no material is listed, resistors may be assumed to be carbon composition; other resistor types are metal film (MF) and wire-wound (WW). An asterisk following a component value indicates that the actual value is factory-selected at time of manufacture; the listed value is nominal.

5-3. Power Supply Regulator Board

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
Complete Assembly		401-15316
C1	Cap., 10 μF/100 V, elect	316-00032
C2	Cap., 25 μF/100 V, elect	316-00081
C3	Cap., .047 μF/200 V, 5%, Mylar	320-00032
C4	Not Used	
C5	Cap., 25 μF/25 V, elect	316-00028
C6	Same as C5	
C7	Not Used	
C8	Same as C1	
C9	Same as C2	
C10	Cap., .1 μF/75 V, cer.,	311-00014
C11	Cap., .001 μF/1 kV, 10%, cer.,	311-00010
C12	Cap., 100 μF/25 V, elect	316-00035
C13	Same as C5	
C14	Same as C12	
C15	Same as C5	
C16	Same as C12	
C17	Same as C12	
C18	Not Used	
C19	Not Used	
C20	Same as C2	
C21	Same as C10	
C22	Same as C5	
C23	Same as C12	
C24	Same as C12	
C25	Same as C5	
CR1	Diode, 1N914B	376-00022
CR2	Same as CR1	
CR3	Diode, Zener, 1N759A	374-00037

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
CR4	Same as CR1	
CR5	Same as CR1	
CR6	Same as CR1	
CR7	Diode, Zener, 1N753A	374-00058
CR8	Same as CR1	
CR9	Diode, 1N4005	376-00034
CR10	Same as CR9	
CR11	Diode, Zener, 1N969B	374-00063
CR12	Same as CR7	
CR13	Same as CR9	
CR14	Same as CR9	
CR15	Same as CR9	
CR16	Same as CR9	
Q1	Transistor, 11724	663-11724
Q2	Not Used	
Q3	Transistor, 2N3904	663-00070
Q4	Transistor, 2N3906	663-00071
Q5	Transistor, 11725	663-11725
Q6	Not Used	
Q7	Same as Q3	
Q8	Not Used	
Q9	Same as Q3	
Q10	Same as Q3	
Q11	Same as Q4	
Q12	Same as Q4	
Q13	Same as Q5	
Q14	Same as Q4	
Q15	Same as Q5	
Q16	Not Used	
Q17	Same as Q4	
Q18	Same as Q5	
Q19	Transistor, 2N4919	663-00106
R1	Res., 220, 1/2 W, 5%	596-00221
R2	Res., 12 K, 1/2W, 5%	596-00123
R3	Res., 3 K, 1/2W, 5%	596-00302
R4	Res., 1, 3W, WW	610-00069
R5	Same as R3	
R6	Potentiometer, 1K, Beckman 62P Series	
R7	Res., 5.1K, 1/2W, 5%	596-00512
R8	Res., 1K, 1/2W, 5%	596-00102
R9	Res., 2K, 1/2W, 5%	596-00202
R10	Res., 5.11K, 1/2W, 1%, MF	618-00020
R11	Same as R10	
R12	Same as R3	
R13	Same as R4	
R14	Same as R4	
R15	Same as R2	
R16	Same as R8	
R17	Res., 120, 1/2W, 5%	596-00121
R18	Same as R7	
R19	Same as R4	
R20	Same as R9	
R21	Res., 1.13K, 1/2W, 1%, MF	618-00080
R22	Res., 1.2K, 1/2W, 1%, MF	618-00023
R23	Res., 1/2W, 5%, (Factory Select)	
R24	Res., 1.5K, 1/2W, 5%	596-00152
R25	Same as R4	
R26	Res., 7.5K, 1/2W, 1%, MF	618-00054
R27	Same as R26	
R28	Same as R17	
R29	Same as R7	
R30	Res., 10, 3W, WW	610-00019
R31	Res., 1.6, 1/2W, 5%	596-00016
R32	Res., 5, 3W, WW	
R33	Same as R3	
R34	Res., 51, 1/2W, 5%	596-00510
R35	Res., 330, 1/2W, 5%	596-00331
R36	Res., 510, 1/2W, 5%	596-00511
R37	Same as R6	
R38	Res., 3.9K, 1/2W, 5%	596-00392
R39	Same as R9	
R40	Res., 5, 5W, WW	610-00115
R41	Res., 3K, 1W, 5%	597-00302
R42	Same as R7	
R43	Same as R36	
R44	Same as R24	
R45	Res., 100, 3W, WW	610-00060
R46	Res., 2K, 1/2W, 1%, MF	618-00005
R47	Res., 2.7K, 1/2W, 5%	596-00272
R48	Same as R21	
R49	Res., 13K, 1/2W, 5%	596-00133
R50	Same as R8	
R51	Same as R32	
R52	Same as R45	
R53	Same as R23	

5-4. OUTPUT BOARD ASSEMBLY

C1	Cap,Cerm,30pF,1KV,20%	311-00005
C2	Cap,Cerm,2.2uF,25V,Mono	311-00019
C3	Cap,Cerm,.001uF,1KV,10%	311-00016
C4	Cap,Cerm,.001uF,1KV,10%	311-00016
C5	Cap,Cerm,.01uF,100V,20%	311-00074
C6	Cap,.1uF,50V	311-00034
C7	Cap,Tant,5.6uF,20V	318-00021
C8	Cap,43uF,Chip	312-14976
C9	Cap,0.1uF,Chip	312-14972
C10	Cap,0.1uF,Chip	312-14972
C11	Cap,390pF,Chip	312-14971
C12	Cap,0.1uF,Chip	312-14972
C13	Cap,0.1uF,Chip	312-14972
C14	Cap,0.1uF,Chip	312-14972
C15	Cap,Cerm,50pF,10%	311-00066
C16	Cap,750pF,2%,Dip Mica	311-00000
C17	Cap,Cerm,10pF,10%	311-00065
C18	Cap,Cerm,10pF,10%	311-00065
C19	Cap,0.1uF	312-14972
C20	Cap,0.1uF	312-14922
C21	Cap,50pF,10%	311-00034

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
C24	Cap,Cerm,.47uF,Mono	311-00020
C25	Cap,Cerm,.01uF,100V,20%	311-00074
C28	Cap,E1,25uF,25V	316-00028
C29	Cap,E1,25uF,50V	316-00078
CR1	Diode,Zener,MP	374-11731
CR2	Diode,1N914B	376-00022
CR3	Diode,Zener,1N759A	374-00037
CR4	Diode,Zener,1N749A	374-00044
CR5	Diode,Zener,MP	374-11733
CR6	Diode,Hot.Car,MBD101	376-00700
CR7	Diode,Hot.Car,MBD101	376-00700
CR8	Diode,Hot.Car,MBD101	376-00700
CR9	Diode,MBD101	376-00700
CR10	Diode,1N914B	376-00022
CR11	Diode,1N270	376-00031
CR12	Diode,1N270	376-00031
CR17	Diode,1N914B	376-00022
CR19	Diode,1N914B	376-00022
CR20	Diode,1N914B	376-00022
CR21	Diode,1N914B	376-00022
CR22	Diode,1N914B	376-00022
CR23	Diode,1N914B	376-00022
CR24	Diode,1N914B	376-00022
CR25	Diode,1N914B	376-00022
K1	Relay,Hi-G 2K-2A-126	584-00000
K2	Relay,Hi-G 2K-2A-126	584-00000
K3	Relay,Hi-G 2K-2A-126	584-00000
K4	Relay,Hi-G 2K-2A-126	584-00000
L1	Choke	335-14686
L2	Choke	335-10956
L3	Choke	335-14686
L4	Choke	335-10956
L5	Choke	335-00000
L6	Choke	335-17303
L7	Choke	335-00000
L8	Choke	335-14686
L9	Choke	000-00000
L10	Choke	000-00000
L15	Choke	335-00000
L16	Choke	335-00000
L17	Choke	335-00000
Q1	Trans	663-11757
Q2	Trans	663-11757
Q3	Trans,MPS2369	663-00112
Q4	Trans,MPS2369	663-00112
Q5	Trans,MPS2369	663-00112
Q6	Trans,MPS2369	663-00112
Q7	Trans	663-11757
Q8	Trans	663-11757
Q9	Trans	663-11757
Q10	Trans	663-11757
Q11	Trans	663-11781
Q12	Trans	663-11781
Q14	Trans,2N3906	663-00071
Q15	Trans,2N3904	663-00070

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
Q16	Trans,~~2N3906~~	663-00071
Q17	Trans,2N3906	663-00071
Q18	Trans,2N4923	663-00107
Q19	Trans,2N4919	663-00106
Q20	Trans,2N3906	663-00071
Q21	Trans,2N3904	663-00070
Q22	Trans,2N3906	663-00071
Q23	Trans,2N5841	663-00108
Q24	Trans,A210	663-00109
Q25	Trans,A210	663-00109
Q26	Trans,A210	663-00109
Q27	Trans,2N4919	663-00106
Q28	Trans	663-11724
Q29	Trans	663-16473
Q30	Trans	663-16474
Q31	Trans,2N3904	663-00070
Q32	Trans,2N3904	663-00070
Q33	Trans,2N3904	663-00070
Q38	Trans	663-11724
Q39	Trans,2N3904	663-00070
Q40	Trans,2N4919	663-00106
Q41	Trans,2N4923	663-00107
Q42	Trans,2N3906	663-00071
R1	Res,200,1/4W,5%	595-00201
R2	Res,2.2K,1/4W,5%	595-00222
R3	Res,680,1/2W,5%	596-00681
R4	Res,2.2K,1/4W,5%	595-00222
R5	Res,100K,1/4W,5%	595-00104
R6	Res,51,1/4W,5%	595-00510
R7	Res,51,1/4W,5%	595-00510
R8	Res,51,1/8W,5%	594-00510
R9	Res,51,1/8W,5%	594-00510
R10	Res,10,1/8W,5%	594-00100
R11	Res,10,1/8W,5%	594-00100
R12	Res,10,1/8W,5%	594-00100
R13	Res,10,1/8W,5%	594-00100
R14	Res,910,1/2W,5%	596-00911
R15	Res,910,1/2W,5%	596-00911
R16	Res,33,1/4W,5%	595-00330
R17	Res,33,1/4W,5%	595-00330
R18	Res,15K,1/4W,5%	595-00153
R19	Res,3.3K,1/4W,5%	595-00332
R20	Res,3.6,1/8W,5%	594-00036
R21	Res,3.6,1/8W,5%	594-00036
R22	Res,470,1/2W,5%	596-00471
R23	Res,20,1/4W,5%	595-00200
R24	Res,20,1/4W,5%	595-00200
R25	Res,360,1/4W,5%	595-00361
R26	Res,360,1/4W,5%	595-00361
R27	Res,39,1/4W,5%	595-00390
R28	Res,62,1/4W,5%	595-00620
R29	Res,100,1/4W,5%	595-00101
R30	Res,39,1/4W,5%	595-00390
R31	Res,221,1/4W,1%	616-00705
R32	Res,15K,1/4W,5%	595-00153

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R33	Res,1.82K,1/4W,1%	616-00713
R34	Res,30,1/4W,5%	595-00300
R35	Res,30,1/4W,5%	595-00300
R36	Res,1.1K,1/4W,1%	616-00712
R37	Res,221,1/4W,1%	616-00705
R38	Res,Factory Select	000-00000
R39	Res,10,1/8W,5%	594-00100
R40	Res,1.5K,1/4W,5%	595-00152
R41	Res,200,1/4W,5%	595-00201
R42	Pot,500	551-00302
R43	Res,1.5K,1/2W,5%	596-00152
R44	Pot,500	551-00302
R45	Res,750,1/4W,5%	595-00751
R46	Res,750,1/4W,5%	595-00751
R47	Res,390,1/4W,5%	595-00391
R48	Res,10,3W,WW	610-00019
R49	Res,270,1/4W,5%	595-00271
R50	Res,5.6,1/8W,5%	594-00056
R51	Res,510,1/4W,5%	595-00511
R52	Res,3.6K,1/4W,5%	595-00362
R53	Res,51,1/4W,5%	595-00510
R54	Res,2K,1/4W,5%	595-00202
R55	Res,100,1/4W,5%	595-00101
R56	Res,30,1/4W,5%	595-00300
R57	Res,6.8K,1/4W,5%	595-00682
R58	Res,1K,1/4W,5%	595-00102
R59	Res,200,3W	000-00000
R60		
R61	Res,10,1/8W,5%	594-00100
R62	Res,300,1/2W,5%	596-00301
R63	Res,300,1/2W,5%	596-00301
R64	Res,27K,1/4W,5%	595-00273
R68	Res,100K,1/4W,5%	595-00104
R69	Res,100K,1/4W,5%	595-00104
R70	Res,620,1W	597-00621
R71	Res,1.2K,1/2W,5%	596-00122
R72	Res,1.2K,1/2W,5%	596-00122
R73	Res,2.2K,1/2W,5%	596-00222
R74	Res,2K,1/4W,5%	595-00202
R75	Res,2K,1/4W,5%	595-00202
R76	Res,2K,1/4W5%	595-00202
R81	Res,6.8K,1/4W,5%	595-00682
R82	Res,6.8K,1/4W,5%	595-00682
R83	Res,6.8K,1/4W,5%	595-00682
R86	Res,510,1/4W,5%	595-00511
R87	Res,3K,1/4W,5%	595-00302
R88	Res,1K,1/4W,5%	595-00102
R89	Res,51,1/4W,5%	595-00510
R91	Res,75,1/8W,5%	594-00750
R92	Res,75,1/8W,5%	594-00750
R93	Res,75,1/8W,5%	594-00750
R94	Res,10,1/2W,1%	000-00000
R95	Res,10,1/2W,1%	000-00000
R96	Res,10,1/2W,1%	000-00000
R97	Res,2K,1/2W,5%	596-00201

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R98	Res,10,1/2W,1%	000-00000
R99	Res,10,1/2W,1%	000-00000
R100	Res,10,1/2W,1%	000-00000
R101	Res,25.5,1W,1%	000-00000
R102	Res,51,1W,1%	000-00000
R103	Res,51,1W,1%	000-00000
R104	Res,25.5,1W,1%	000-00000
R105	Res,51,1/8W,5%	594-00510
R106	Res,51,1/8W,5%	594-00510
R107	Res,10,1/4W,5%	595-00100
R108	Res,65,15W,1%	000-00000
R109	Res,10,1/4W,5%	595-00100
R110	Res,390,1W,5%	597-00391
R111	Res,1.5K,1/4W,5%	595-00152
R112	Res,Factory Select	000-000000
R113	Res,511,1/4W,1%,MF	616-00720
R114	Res,10,1W,5%	597-00100
R115	Res,1.3K,1/2W,5%	596-00132
R116	Res,330,2W,5%	598-00331
R117	Res,511,1/4W,1%,MF	616-00720
R118	Res,511,1/4W,1%,MF	616-00720
R119	Res,511,1/4W,1%,MF	616-00720
R120	Res,1.3K,1/2W,5%	596-00132
R121	Res,10,1W,5%	597-00100
R122	Res,330,2W,5%	598-00331
R123	Res,511,1/4W,1%,MF	616-00720
R125	Res,2.4K,1/2W,5%	596-00242
R126	Res,75,2W,1%	000-00000
R127	Res,75,2W,1%	000-00000
R128	Res,150,2W,1%	000-00000
R129	Res,150,2W,1%	000-00000
R130	Res,93.1,2W,1%	000-00000
R131	Res,165,2W,1%	000-00000
R132	Res,165,2W,1%	000-00000
R133	Res,165,2W,1%	000-00000
R134	Res,165,2W,1%	000-00000
R135	Res,93.1,2W,1%	000-00000
R136	Res,93.1,2W,1%	000-00000
R137	Res,165,2W,1%	000-00000
R138	Res,165,2W,1%	000-00000
R139	Res,82.5,2W,1%	000-00000
R140	Res,82.5,2W,1%	000-00000
R141	Res,165,2W,1%	000-00000
R142	Res,165,2W,1%	000-00000
R144	Res,2.2K,1/4W,5%	595-00222
R145	Res,2.7,1/4W,5%	595-00027
R149	Res,6.8K,1/4W,5%	595-00682
R150	Res,910,1/2W,5%	596-00911
R151	Res,910,1/2W,5%	596-00911
R152	Res,470,1/2W,5%	596-00471
R153	Res,1K,1/2W,5%	596-00102
T1	Transformer	651-12570
T2	Balun	651-19186

5-5. TIMING BOARD ASSEMBLY

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
Complete Assembly		402-15172
C1	Cap., .005 μF/500 V, 10%, cer	311-00069
C2	Same as C1	
C3	Same as C1	
C4	Cap., 50pF/500 V, 10%, cer	311-00066
C5	Cap., 75pF/1KV, 10%, cer	311-00025
C6	Same as C1	
C7	Same as C1	
C8	Cap., .001 μF/1KV, 10%, cer	311-00010
C9	Same as C1	
C10	Cap., .1 μF/75 V, cer	311-00014
C11	Same as C8	
C12	Cap., 100pF/1KV, 10%, cer	311-00007
C13	Same as C4	
C14	Same as C1	
C15	Same as C4	
C16	Cap., 500 μF/500 V, cer	311-00073
C17	Cap., .01 μF/600 V, cer	311-00012
C18	Same as C8	
C19	Cap., 25 μF/25 V, elect	316-00028
C20	Same as C19	
C21	Same as C4	
CR1	Diode	376-11764
CR2	Same as CR1	
CR3	Diode, Matched Pair	374-11731
CR4	Same as CR3	
CR5	Not Used	
CR6	Diode, 1N914B	376-00022
CR7	Same as CR1	
CR8	Diode, Matched Pair	
CR9	Same as CR8	
CR10	Diode	376-11742
CR11	Same as CR10	
CR12	Diode, Matched Pairs	374-11730
CR13	Same as CR10	
CR14	Same as CR6	
CR15	Same as CR6	
CR16	Same as CR6	
CR17	Same as CR6	
CR18	Same as CR3	
CR19	Same as CR3	
CR20	Same as CR1	
CR21	Same as CR1	
CR22	Same as CR1	
CR23	Same as CR1	
CR24	Same as CR10	
CR25	Diode, 1N751A	374-00022
CR26	Same as CR1	
CR27	Same as CR1	
CR28	Same as CR6	
CR29	Same as CR10	
CR30	Same as CR10	
CR31	Same as CR10	
CR32	Same as CR12	
CR33	Same as CR25	
CR34	Same as CR12	
CR35	Same as CR12	
CR36	Same as CR25	
CR37	Same as CR10	
CR38	Same as CR10	
CR39	Same as CR10	
CR40	Same as CR10	
CR41	Same as CR10	
CR42	Same as CR10	
CR43	Same as CR1	
CR44	Same as CR10	
CR45	Same as CR10	
CR46	Same as CR10	
CR47	Same as CR10	
CR48	Same as CR12	
CR49	Same as CR10	
CR50	Same as CR12	
CR51	Same as CR25	
CR52	Same as CR10	
CR53	Same as CR10	
CR54	Same as CR6	
CR55	Diode, 1N749A	374-00044
CR56	Same as CR6	
CR57	Same as CR55	
L1	Inductor, .22 μH, Fixed	335-00014
L2	Same as L1	
L3	Same as L1	
Q1	Transistor	663-11749
Q2	Transistor	663-11781
Q3	Same as Q2	
Q4	Transistor	663-11757
Q5	Same as Q4	

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
Q6	Same as Q4	
Q7	Same as Q4	
Q8	Transistor, MPS 2369	663-00112
Q9	Same as Q8	
Q10	Same as Q8	
Q11	Same as Q8	
Q12	Same as Q8	
Q13	Same as Q8	
Q14	Same as Q8	
Q15	Same as Q4	
Q16	Same as Q4	
Q17	Same as Q4	
Q18	Same as Q1	
Q19	Transistor, 2N3904	663-00070
Q20	Same as Q4	
Q21	Same as Q4	
Q22	Transistor, 2N3906	663-00071
Q23	Same as Q19	
Q24	Same as Q22	
Q25	Same as Q4	
Q26	Same as Q4	
Q27	Same as Q4	
Q28	Same as Q4	
Q29	Same as Q4	
Q30	Same as Q4	
Q31	Same as Q4	
Q32	Same as Q4	
Q33	Same as Q4	
Q34	Same as Q4	
Q35	Same as Q4	
Q36	Same as Q4	
R1	Potentiometer, 100	551-00036
R2	Res., 220, 1/4W, 5%	595-00221
R3	Same as R2	
R4	Res., 1.5K, 1/4W, 5%	595-00152
R5	Res., 330, 1/2W, 5%	596-00331
R6	Same as R4	
R7	Res., 200, 1/4W, 5%	595-00201
R8	Res., 1K, 1/4W, 5%	595-00102
R9	Res., 10K, 1/4W, 5%	595-00103
R10	Res., 160, 1/4W, 5%	595-00161
R11	Same as R4	
R12	Same as R4	
R13	Res., 24, 1/4W, 5%	595-00240
R14	Same as R13	
R15	Res., 1.3K, 1/4W, 5%	595-00132
R16	Res., 470, 1/4W, 5%	595-00471
R17	Res., 51, 1/4W, 5%	595-00510
R18	Res., 1.1K, 1/4W, 5%	595-00112
R19	Same as R8	
R20	Res., 5.1K, 1/4W, 5%	595-00512
R21	Res., 510, 1/4W, 5%	595-00511
R22	Same as R9	
R23	Same as R17	
R24	Same as R17	
R25	Res., 150, 1/4W, 5%	595-00151
R26	Res., 2K, 1/4W, 5%	595-00202
R27	Same as R15	
R28	Not Used	
R29	Not Used	
R30	Same as R18	
R31	Same as R16	
R32	Res., 560, 1/4W, 5%	595-00561
R33	Same as R8	
R34	Res., 430, 1/2W, 5%	596-00431
R35	Res., 1.2M, 1/4W, 5%	595-00125
R36	Same as R35	
R37	Same as R34	
R38	Res., 330, 1/4W, 5%	595-00331
R39	Same as R19	
R40	Res., 430, 1/4W, 5%	595-00431
R41	Same as R26	
R42	Res., 510, 1/2W, 5%	596-00511
R43	Same as R17	
R44	Same as R8	
R45	Same as R4	
R46	Res., 30, 1/4W, 5%	595-00300
R47	Same as R8	
R48	Same as R17	
R49	Same as R20	
R50	Same as R8	
R106	Same as R19	
R107	Same as R26	
R108	Same as R78	
R109	Res., 620, 1/2W, 5%	596-00621
R110	Same as R80	
R111	Same as R4	
R112	Res., 200, 1/2W, 5%	596-00201
R113	Same as R78	
R114	Same as R13	
R115	Same as R13	
R116	Same as R7	
R117	Same as R96	
R118	Same as R26	
R119	Same as R18	
R120	Res., Factory Select	
R121	Res., 360, 1W, 5%	597-00361
R122	Same as R26	
R123	Res., 2.7, 1/4W, 5%	595-00027
R124	Same as R38	
R125	Same as R4	
R51	Same as R20	
R52	Res., 620, 1/4W, 5%	595-00621
R53	Res., 110, 1/2W, 5%	596-00111
R54	Same as R53	
R55	Res., 3.3K, 1/4W, 5%	595-00332
R56	Same as R4	
R57	Res., 5.1, 1/4W, 5%	595-00051
R58	Same as R4	
R59	Res., 390, 1/2W, 5%	596-00391
R60	Same as R4	

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R61	Same as R57	
R62	Res., 2.2K, 1/4W, 5%	595-00222
R63	Same as R8	
R64	Same as R46	
R65	Same as R46	
R66	Same as R4	
R67	Same as R46	
R68	Same as R32	
R69	Res., 10, 1/4W, 5%	595-00100
R70	Same as R21	
R71	Res., 820, 1/4W, 5%	595-00821
R72	Res., 15K, 1/4W, 5%	595-00153
R73	Same as R72	
R74	Same as R26	
R75	Same as R62	
R76	Same as R72	
R77	Same as R16	
R78	Res., 3K, 1/4W, 5%	595-00302
R79	Same as R78	
R80	Res., 560, 1/2W, 5%	596-00561
R81	Same as R4	
R82	Same as R5	
R83	Same as R78	
R84	Same as R78	
R85	Not Used	
R86	Same as R80	
R87	Same as R4	
R88	Same as R5	
R89	Same as R78	
R90	Same as R13	
R91	Same as R13	
R92	Same as R13	
R93	Same as R13	
R94	Same as R7	
R95	Same as R18	
R96	Res., 100, 1/4W, 5%	595-00101
R97	Res., 430, 1/4W, 5%	595-00431
R98	Same as R25	
R99	Same as R7	
R100	Res., 100, 1/4W, 5%	595-00101
R101	Same as R18	
R102	Same as R17	
R103	Same as R17	
R104	Same as R40	
R105	Same as R25	

5-6 FRONT PANEL ASSEMBLY

Complete Assembly		251-16847
R201	Potentiometer, 10K	550-00012
R202	Potentiometer, 250	550-00017
R203	Same as R202	
R204	Same as R201	
R205	Pot., 500, 2W, 10%	550-00001
R206	Same as R201	
R207	Potentiometer, 5K	550-00003
R209	Pot., 2.5K, 2W, 10%	550-00009
R220	Res., 20K, 1/4W, 5%	595-00203
R222	Res., 51, 1/2W, 5%	596-00510
R223	Res., 120, 1/4W, 5%	595-00121
R224	Same as R223	
R225	Res., 270, 1/4W, 5%	595-00271
R226	Res., 68, 1/4W, 5%	595-00680
S202	Switch, Pushbutton	635-00014
S203	Switch, Toggle	630-00019
S204	Same as S203	
S205	Switch, Toggle	630-00013
S206	Same as S205	
S212	Switch, Toggle, DPDT	630-00006
J202	Connector, BNC	721-00013
	Attenuator Switch Assembly	626-16891
R210	Res., 1K, 1/4W, 5%	595-00102
R221	Res., 20K, 1/2W, 5%	596-00203
S213	Switch, Toggle	630-00015
	Pilot Light	510-00008
	Knob Med	433-00008
	Knob Small	443-00026

5-7 MAIN CHASSIS ASSEMBLY

Complete Assembly	225-16849
Chassis Main	254-15838
Silkscreen, Chassis	144-16956
Terminal Strip	484-00036
Terminal Strip Plate	484-00037
Terminal Strip Cover	258-13061
Transistor, Mounting Kit	490-00001
Transformer	650-10630
Cap., 3300 μF/50 V	316-00079
Cap., 1500 μF/75 V	316-00049
Transistor, 2N3055	663-00073
Transistor, 2N4923	663-00107
Transistor, 11705	663-11705
Terminal Strip Jumper	484-00023
Backmatch Assembly	693-16893
Delay Line Assy (1)	708-16894
Cap., Bracket	410-00034
Cap., Cover	330-00006
Terminal	484-00027
#6-32 x 2/8 BHMS	203-00008
#8-32 x 3/8 BHMS	204-00004
#4-40 x 3/8 BHMX	202-00012
#6-40 x 5/8 BHMS	202-00025
#6-32 x 1/2 BHMS	203-00013
#6 flatwasher	215-00020
#4-40 Kepnut	

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
	#6-32 Kepnut	240-00002
	#8-32 Kepnut	240-00003
	#10-32 Kepnut	240-00004
	Cable Clamp, Nylon, 5/16 (1)	410-00008
	Solder Lug #10 x 1 (3)	460-00004
	Spacer, Hex 4-40 x 1/4 (2)	475-00025
	Cradle (2)	410-00014
	Clip	410-00015

5-8 REAR PANEL ASSEMBLY

	Complete Assembly	253-16848
J101	Receptacle, a.c.	700-00033
F101	Fuseholder	396-00001
F102	Same as F101	
	Fan Assembly	570-00008
	Fuse 1.5 AMP Slo-Blo	398-00013

5-9 DELAY SWITCH

	Complete Assembly	625-16853
C216	Cap., 39 μF, 10% tant	318-00029
C217	Same as C216	
C218	Cap., 18 μF, 35 V, 10%, tant.	
C219	Cap., 3.3 μF, 35 V, 10%, tant.	
C220	Cap., .75 μF/200 V 5%, mylar	320-00056
C221	Cap., .18 μF/200 V 5%, mylar	320-00033
C222	Cap., .033 μF/200 V, 5%, mylar	320-00029
C223	Cap., 7500 pF/500 V, 5%, poly	
C224	Cap., 1800 pF/500 V 5%, poly	
C225	Cap., 300 pF 1KV 10%	311-00078
R214	Res., 5.1, 1/4W, 5%	595-00051
R215	Same as C214	

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO

5-10 WIDTH SWITCH

	Complete Assembly	625-16854
C226	Cap., 39 μF, 10%, tant	318-00029
C227	Same as C226	
C228	Cap., 18 μF, 35 V, 10%, tant.	
C229	Cap., 3.3 μF, 35 V, 10%, tant.	
C230	Cap., .75 μF/200 V, 5%, mylar	320-00056
C231	Cap., .18 μF/200 V, 5%, mylar	320-00033
C232	Cap., .033 μF/200 V, 5%, mylar	320-00029
C233	Cap., 7500 pF/500 V, 5% poly	
C234	Cap., 1800 pF/500 V, 5%	
C235	Cap., 300 μF, 1KV, 10%, cer	311-00078
R216	Res., 5.1, 1/4W, 5%	595-00051
R217	Same as R216	

5-11 FREQUENCY RANGE SWITCH

	Complete Assembly	625-16855
C201	Cap., 47 μF/20 V, 20%, tant	318-00001
C202	Cap., 15 μF/20 V, 20%, tant	318-00009
C203	Same as C201	
C204	Same as C201	
C206	Cap., 4.7 μF620 V, 20%, tant	318-00002
C207	Cap., 1.5 μF/200 V, 5%, mylar	320-00037
C208	Cap., 0.47 μF/200 V, 5%, mylar	320-00035
C209	Cap., 0.15 μF/200 V, 5%, mylar	320-00036
C210	Cap., 0.047 μF/200 V, 5%, mylar	320-00032
C211	Cap., 0.015 μF/200 V, 5%, mylar	320-00031
C212	Cap., 4300 pF, poly	326-00017
C213	Cap., .0015 μF/1KV, 10%, cer	311-00033
C214	Cap., 400 pF/1KV, 10%, cer	311-00026
C215	Cap., 10 pF/1KV, 10%, cer	311-00001
R210	Res., 1K, 1/4W, 5%	595-00102
R212	Res.,5.1, 1/4W, 5%	595-00051
R213	Same as R212	

SECTION 6
DRAWINGS

6-1 GENERAL INFORMATION

This section of the manual contains drawings of the subassemblies and circuits in the E-H Model 135A Pulse Generator. The drawings ccontain the component circuit designators and show the location of the wiring terminals. The theory of operation is located in Section 3 and the parts list is located in Section 5.

Figure 6-1 is an outline dimension drawing of the bench top configuration. Figures 6-2 through 6-4 are the component location drawings. Refer to the drawings to determine the location of any specific component.

6-2 SCHEMATIC DIAGRAMS

There are five schematics following the component location drawings. Insofar as possible, the convention of signal-flow from left to right and current-flow from bottom to top are adhered to in the diagrams. Drawing number D-16512 is a master schematic (not a wiring diagram) showing the interconnection of all subassemblies and controls.

Component symbology and nomenclature follow generally-accepted practices. Resistance is given in ohms. Capacitor values less than 1 are in microfarads and more than 1 are in picofarads unless otherwise labeled Multi-deck rotary switches are shown schematically inline.

6-3 RACKMOUNT CONVERSION

In order to convert the Model 135A for rackmounting the following procedure should be adhered to.

1. Remove the cabinet and refer to Figure 6-1.

2. Remove the rear escutcheon panel.

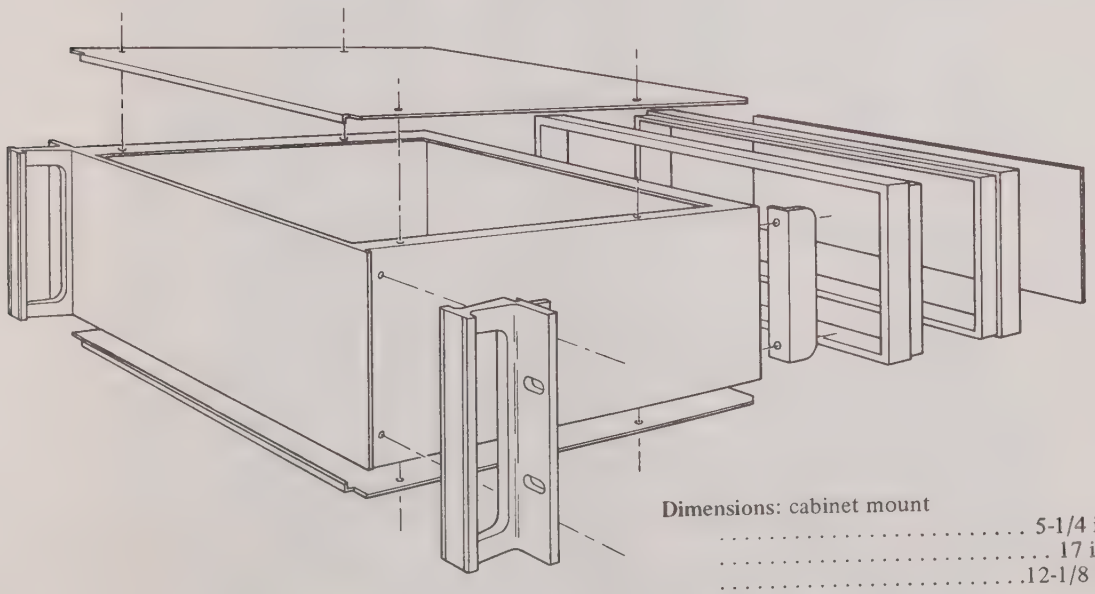
3. Remove both the front and rear end frames by sliding them to the rear of the instrument.

4. Install new top and bottom covers.

5. Install the flanges (2) on the rear of the Model 135A in the old escutcheon panel holes.

6. Install the handles (2) on the front of the Model 135A in the old front end frame holes.

This completes the modification for rackmounting.



Dimensions: cabinet mount
. . . . . 5-1/4 in (13.3 cm) high
. . . . . 17 in (43.2 cm) wide
. . . . . 12-1/8 in (308 cm) deep
Rackmount conversion
Mounting holes center-to-center
Vertical . . . . . 2.25 in (5.52 cm)
Horizontal . . . . . 18.30 in (46.50 cm)

EH-L0414

Figure 6-1 Rackmount Conversion and Outline Dimensions

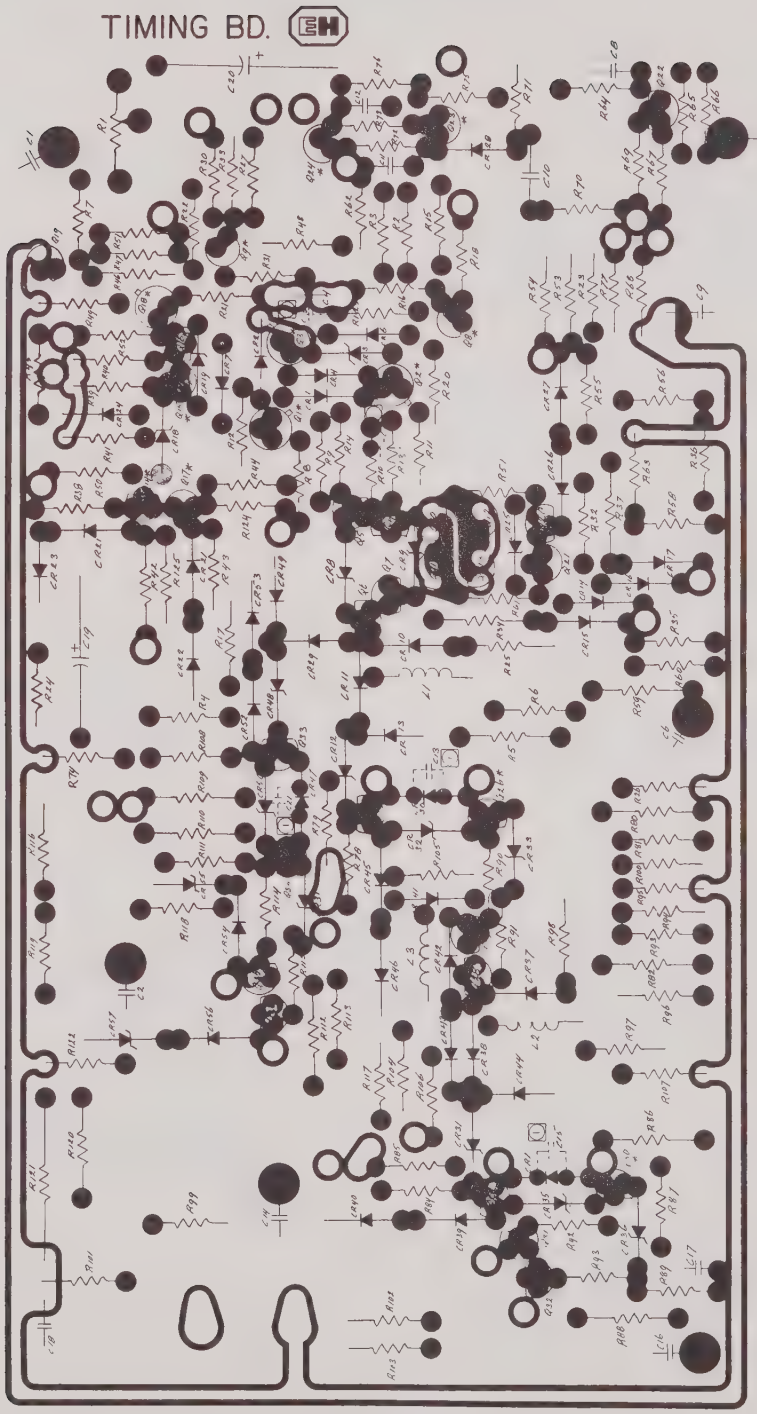


Figure 6-2 Timing Board Assembly Drawing

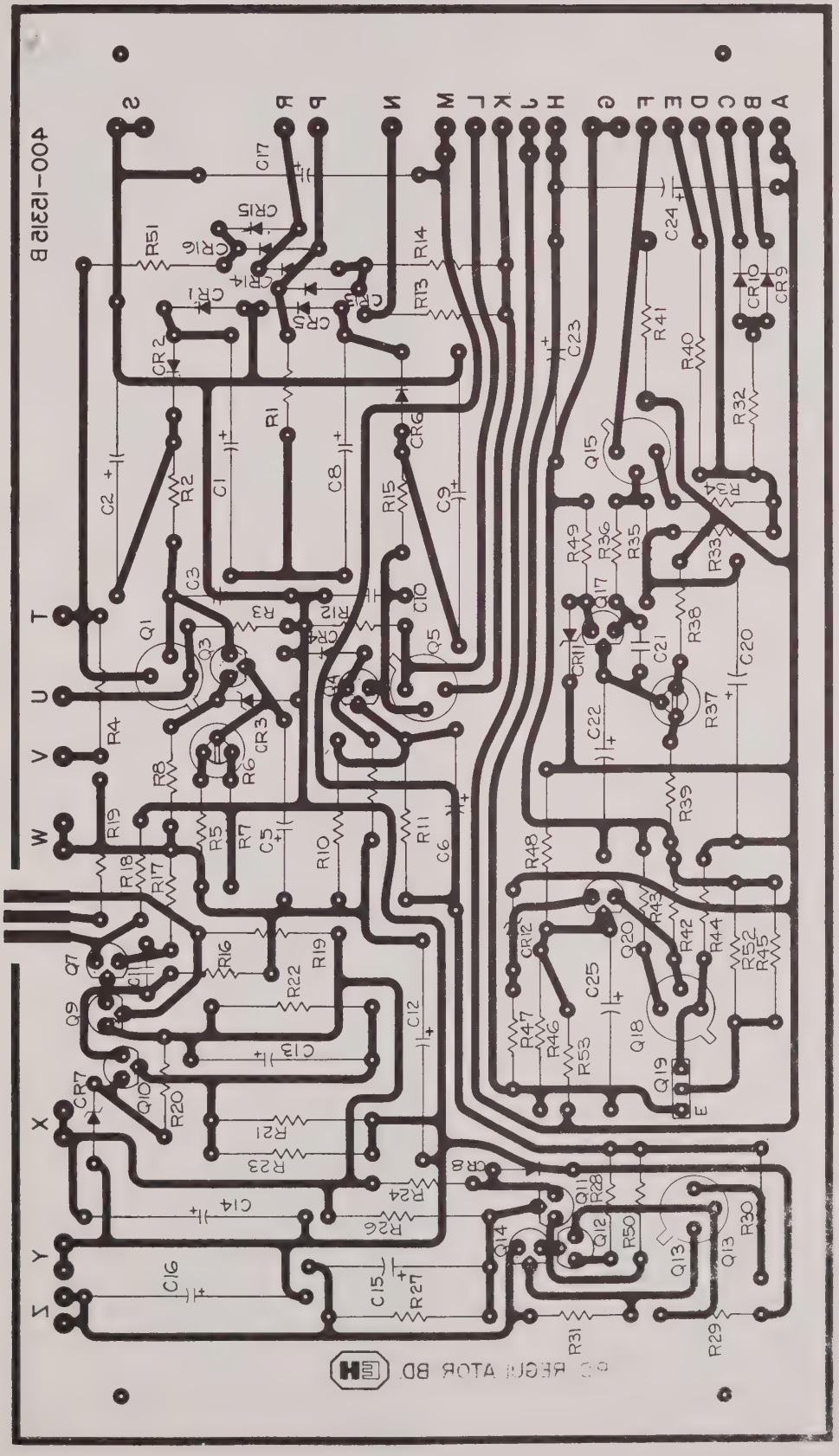
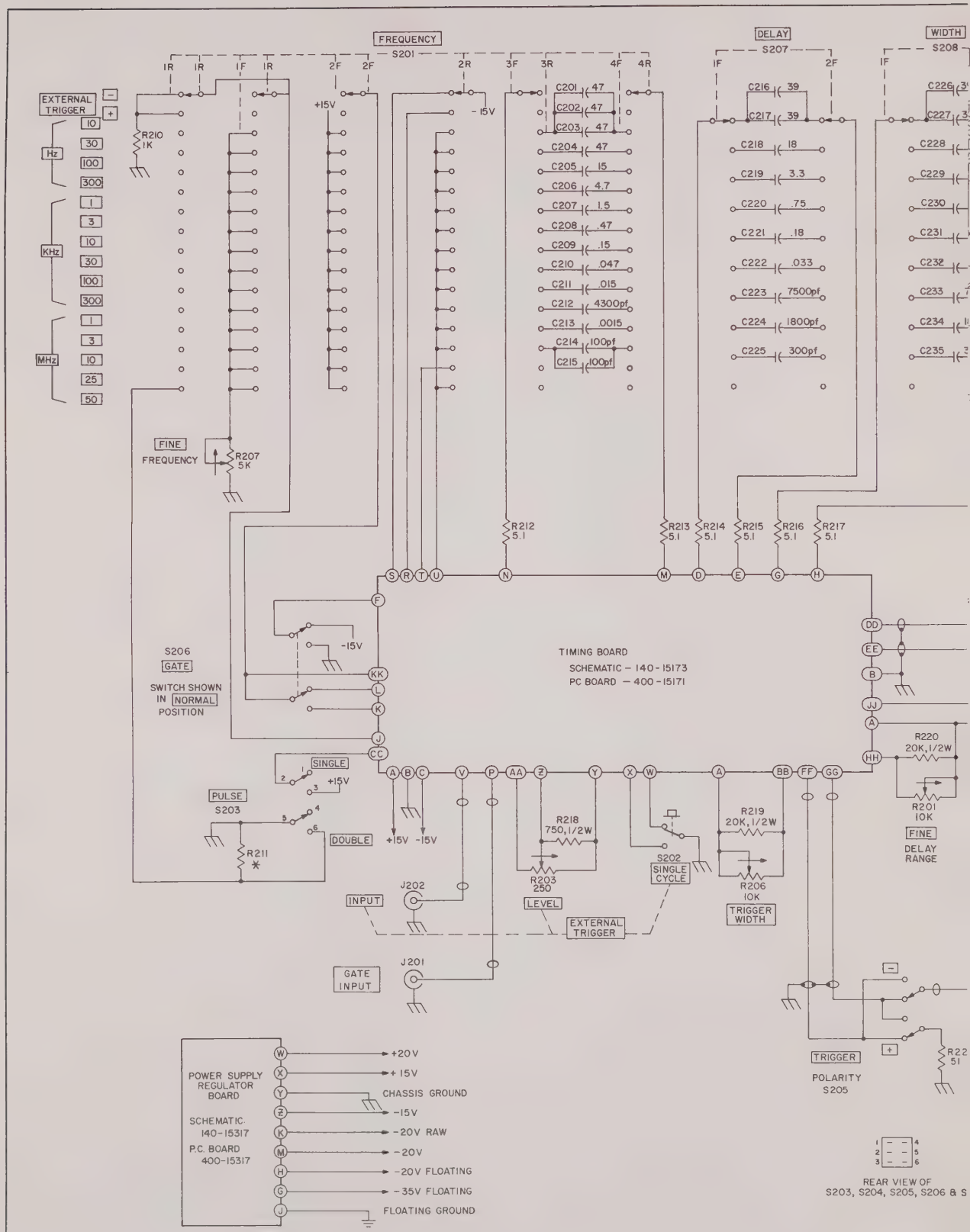
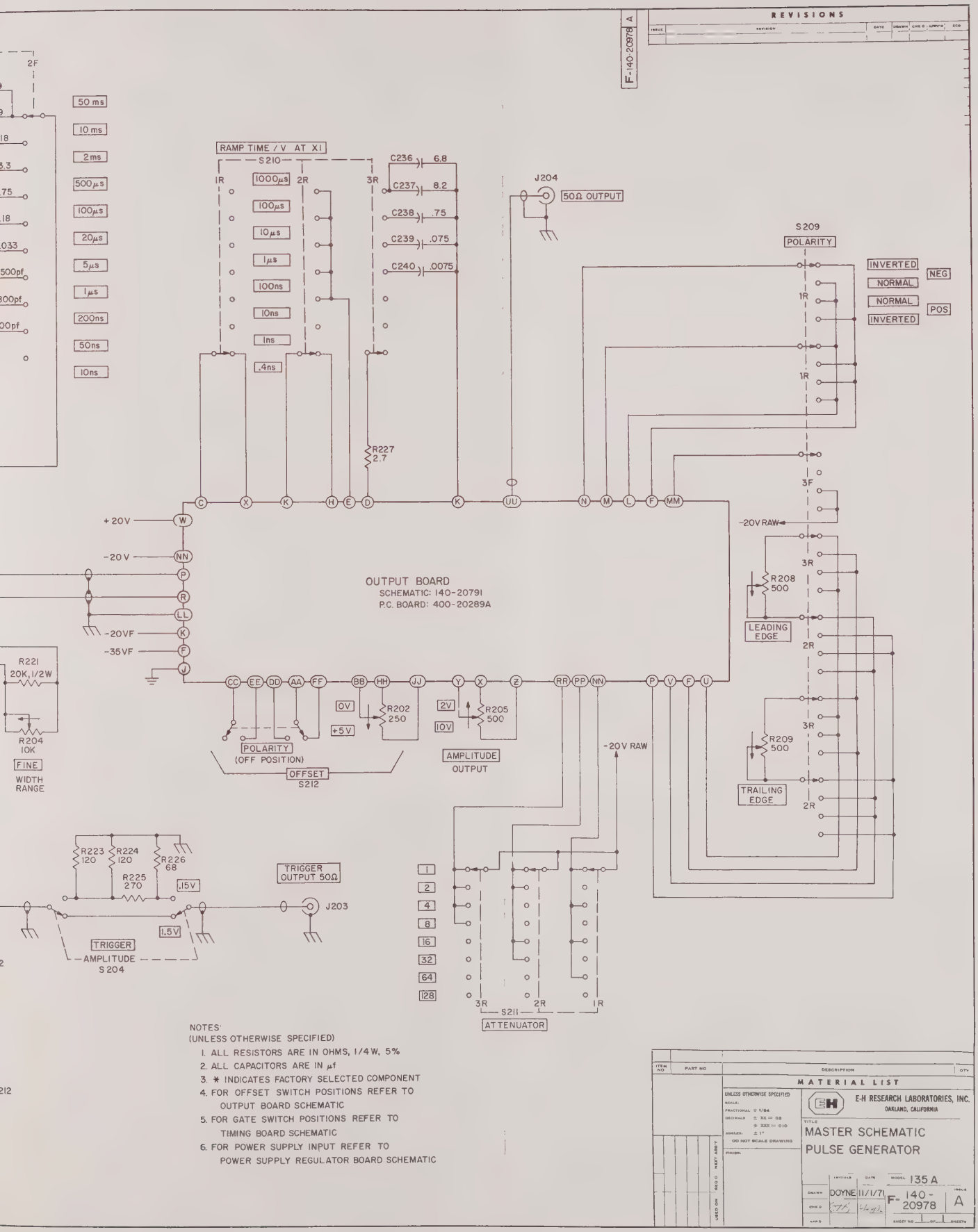
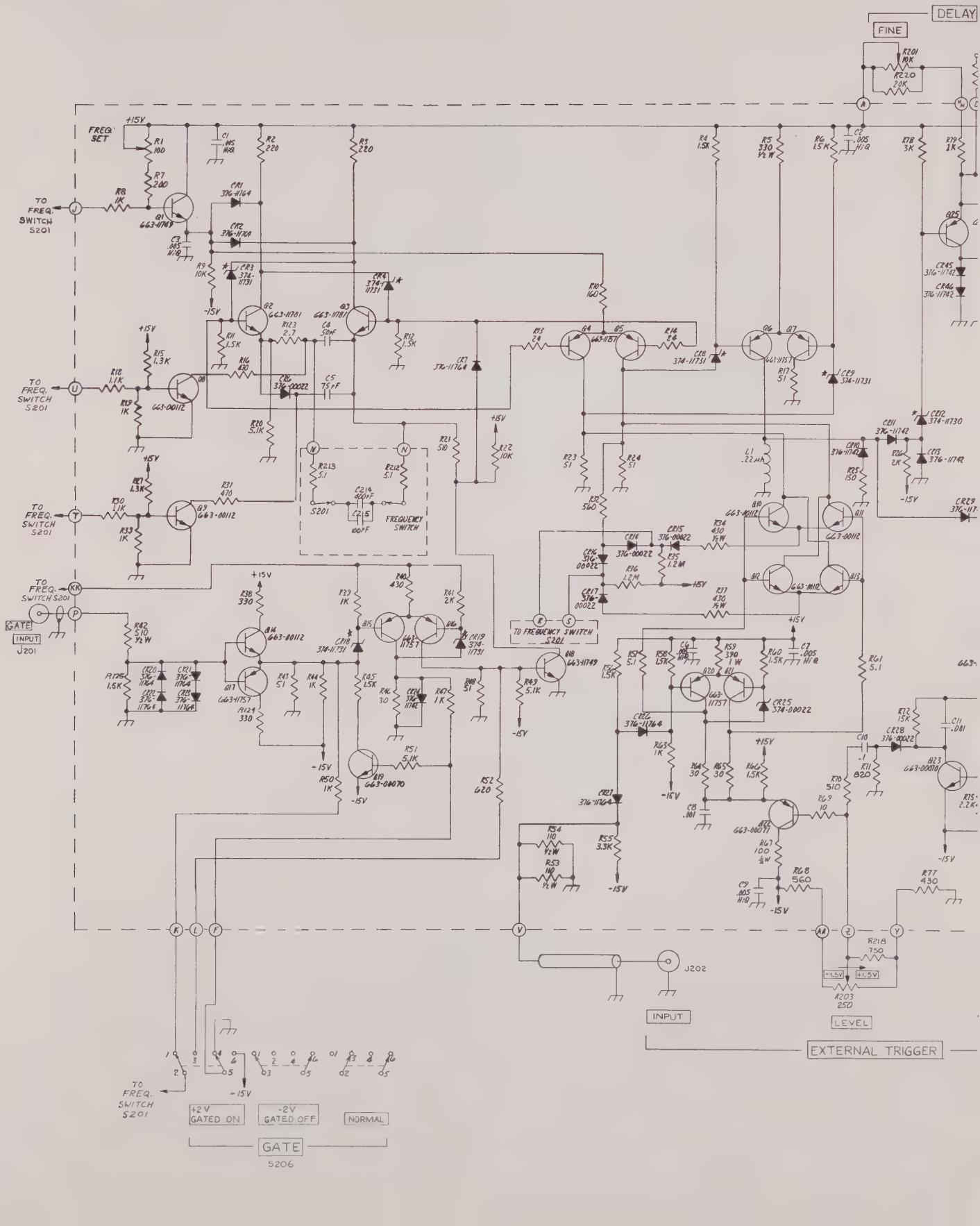
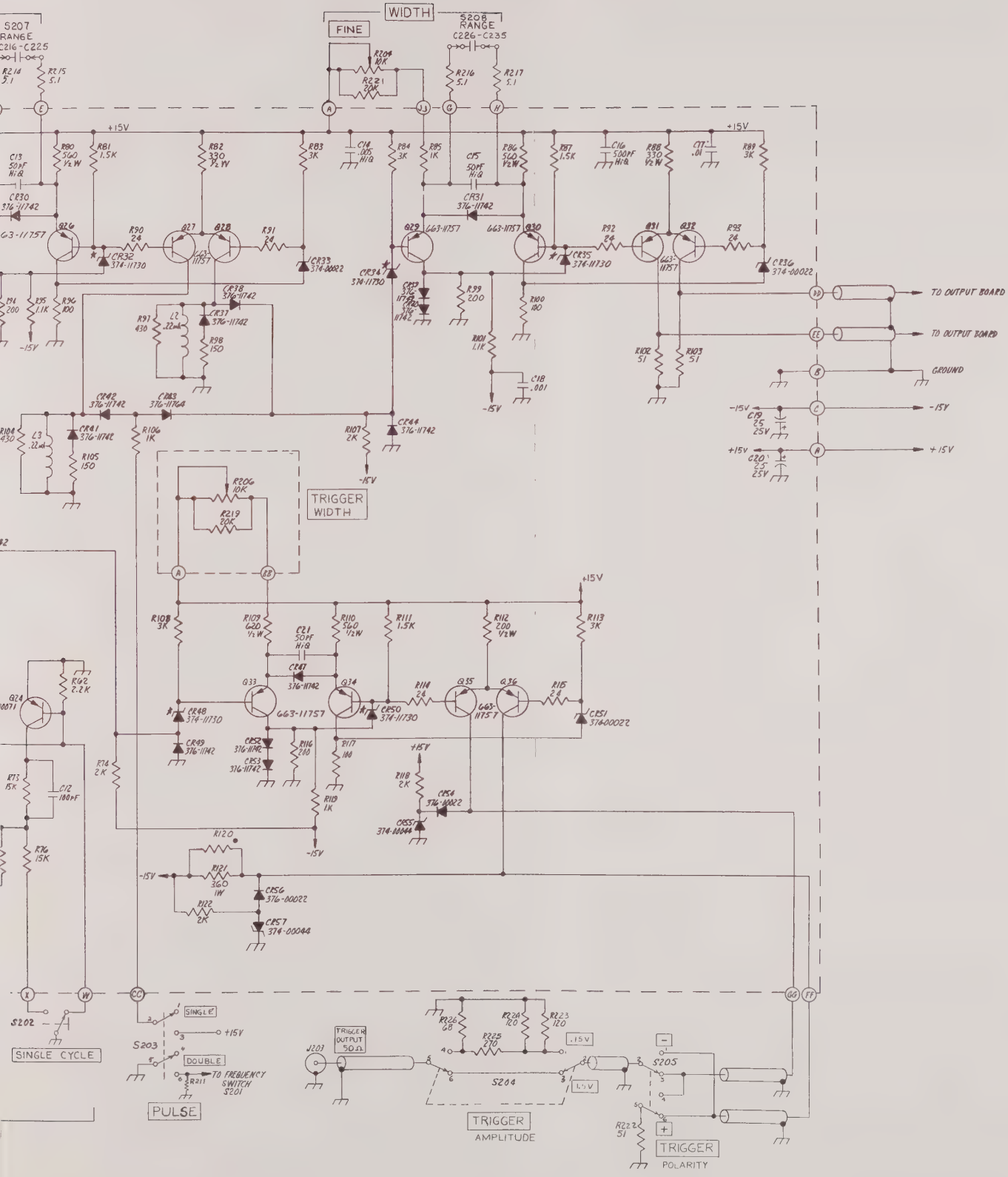


Figure 6-3 Power Supply Board Assembly Drawing


FREQUENCY
S201
DELAY
S207
WIDTH
S208
EXTERNAL TRIGGER
Hz
KHz
MHz
R210 1K
FINE FREQUENCY
R207 5K
+15V
-15V
C201 47
C202 47
C203 47
C204 47
C205 15
C206 4.7
C207 1.5
C208 .47
C209 .15
C210 .047
C211 .015
C212 4300pf
C213 .0015
C214 100pf
C215 100pf
C216 39
C217 39
C218 18
C219 3.3
C220 .75
C221 .18
C222 .033
C223 7500pf
C224 1800pf
C225 300pf
R212 5.1
R213 5.1
R214 5.1
R215 5.1
R216 5.1
R217 5.1
S206
GATE
SWITCH SHOWN IN NORMAL POSITION
TIMING BOARD
SCHEMATIC - 140-15173
PC BOARD - 400-15171
SINGLE
PULSE
S203
DOUBLE
R211
R218 750, 1/2W
R203 250
LEVEL
S202
SINGLE CYCLE
R219 20K, 1/2W
R206 10K
TRIGGER WIDTH
R220 20K, 1/2W
R201 10K
FINE
DELAY RANGE
INPUT
J202
EXTERNAL TRIGGER
GATE INPUT
J201
TRIGGER
POLARITY
S205
POWER SUPPLY REGULATOR BOARD
SCHEMATIC 140-15317
P.C. BOARD 400-15317
+20V
+15V
CHASSIS GROUND
-15V
-20V RAW
-20V
-20V FLOATING
-35V FLOATING
FLOATING GROUND
REAR VIEW OF
S203, S204, S205, S206 &


REVISIONS
F-140-20978 A
RAMP TIME / V AT X1
S210
1R
2R
3R
1000µs
100µs
10µs
1µs
100ns
10ns
1ns
.4ns
C236 6.8
C237 8.2
C238 .75
C239 .075
C240 .0075
R227 2.7
J204
50Ω OUTPUT
S209
POLARITY
INVERTED
NORMAL
NORMAL
INVERTED
NEG
POS
50 ms
10 ms
2ms
500µs
100µs
20µs
5µs
1µs
200ns
50ns
10ns
+20V
-20V
-20VF
-35VF
-20V RAW
R208 500
LEADING EDGE
R209 500
TRAILING EDGE
R221 20K, 1/2W
R204 10K
FINE
WIDTH
RANGE
OUTPUT BOARD
SCHEMATIC: 140-20791
P.C. BOARD: 400-20289A
0V
+5V
R202 250
POLARITY
(OFF POSITION)
OFFSET
S212
2V
10V
R205 500
AMPLITUDE
OUTPUT
R223 120
R224 120
R226 68
R225 270
.15V
1.5V
TRIGGER
AMPLITUDE
S 204
TRIGGER
OUTPUT 50Ω
J203
1
2
4
8
16
32
64
128
S211
ATTENUATOR
NOTES
(UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN µf
3. * INDICATES FACTORY SELECTED COMPONENT
4. FOR OFFSET SWITCH POSITIONS REFER TO OUTPUT BOARD SCHEMATIC
5. FOR GATE SWITCH POSITIONS REFER TO TIMING BOARD SCHEMATIC
6. FOR POWER SUPPLY INPUT REFER TO POWER SUPPLY REGULATOR BOARD SCHEMATIC
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
MASTER SCHEMATIC
PULSE GENERATOR
MODEL 135 A
DOYNE 11/1/7
F- 140 - 20978
A

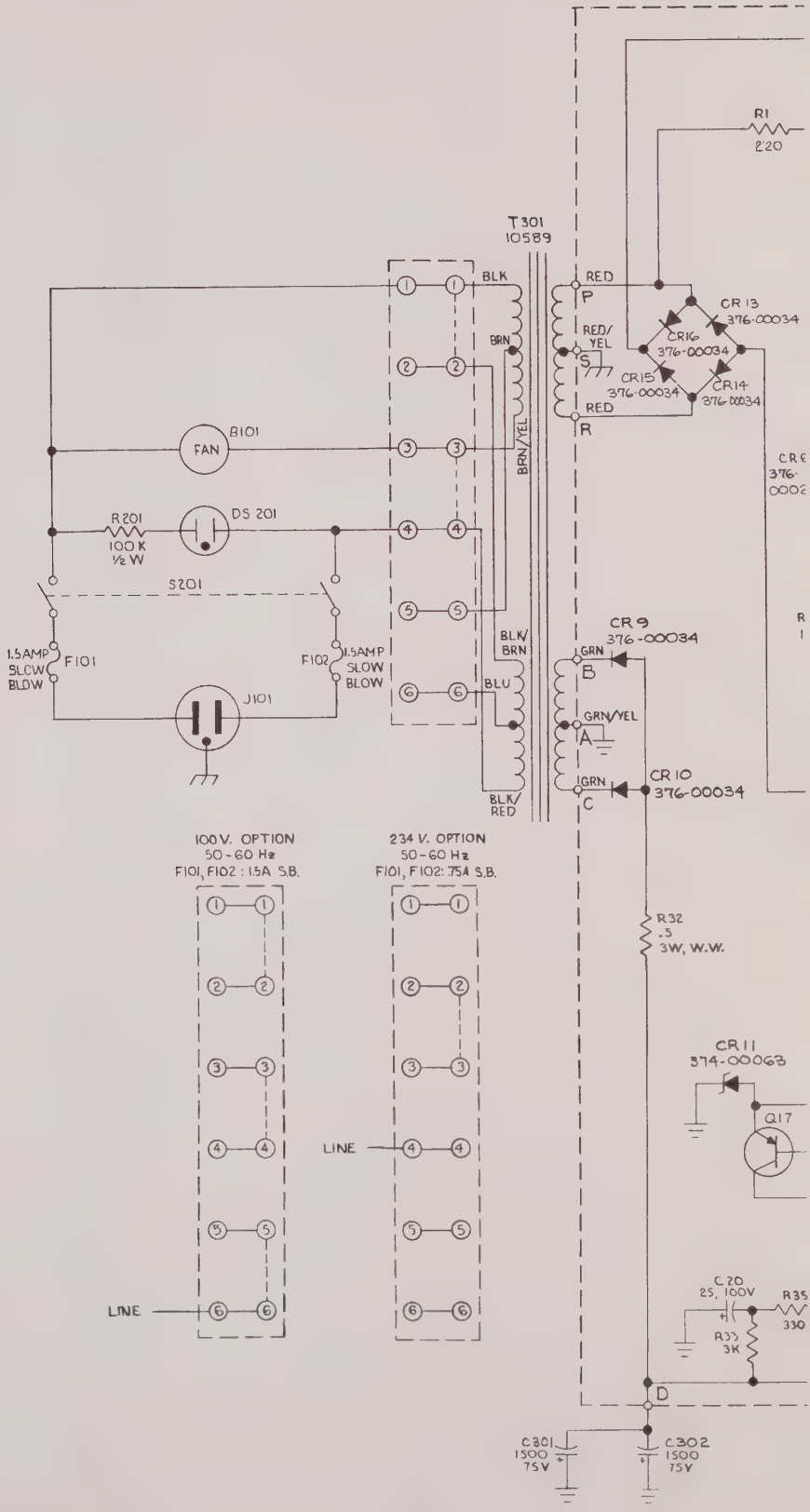

DELAY
FINE
FREQ SET
+15V
-15V
TO FREQ. SWITCH S201
INPUT J201
GATE
FREQUENCY SWITCH
TO FREQUENCY SWITCH S201
J202
INPUT
LEVEL
EXTERNAL TRIGGER
+2V GATED ON
-2V GATED OFF
NORMAL
GATE
S206

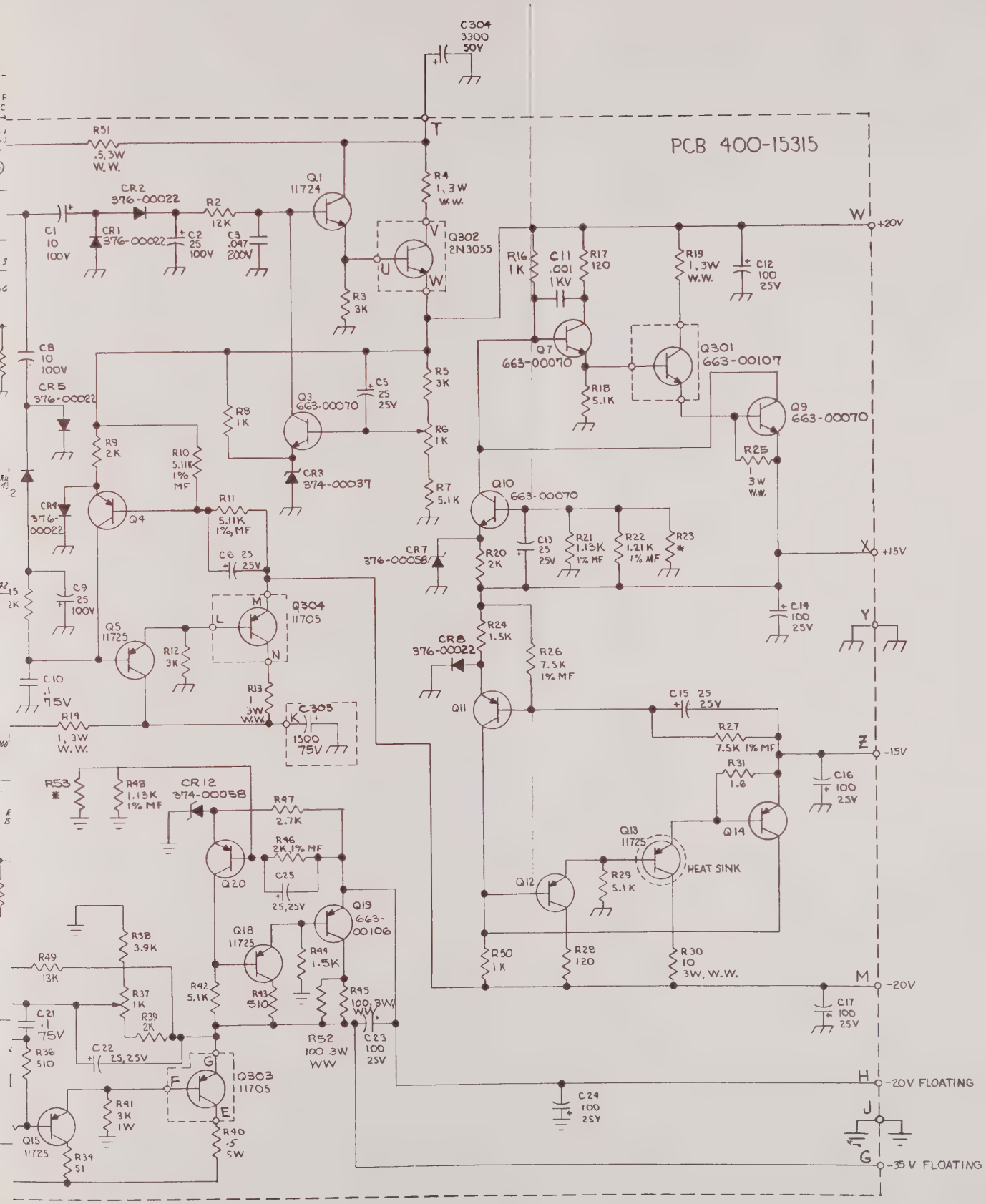


TIMING BOARD SCHEMATIC

(A)

F-15173


T301
10589
BLK
BRN
BRN/YEL
RED
RED/
YEL
RED
P
S
R
CR13
376-00034
CR16
376-00034
CR15
376-00034
CR14
376-00034
R1
220
B101
FAN
R201
100K
½W
DS 201
S201
1.5AMP
SLOW
BLOW
F101
F102
1.5AMP
SLOW
BLOW
J101
BLK/
BRN
BLU
BLK/
RED
CR9
376-00034
GRN
B
GRN/YEL
A
GRN
C
CR10
376-00034
100V. OPTION
50-60 Hz
F101, F102 : 1.5A S.B.
234 V. OPTION
50-60 Hz
F101, F102: .75A S.B.
LINE
LINE
R32
.5
3W, W.W.
CR11
374-00063
Q17
C20
25, 100V
R33
3K
D
C301
1500
75V
C302
1500
75V

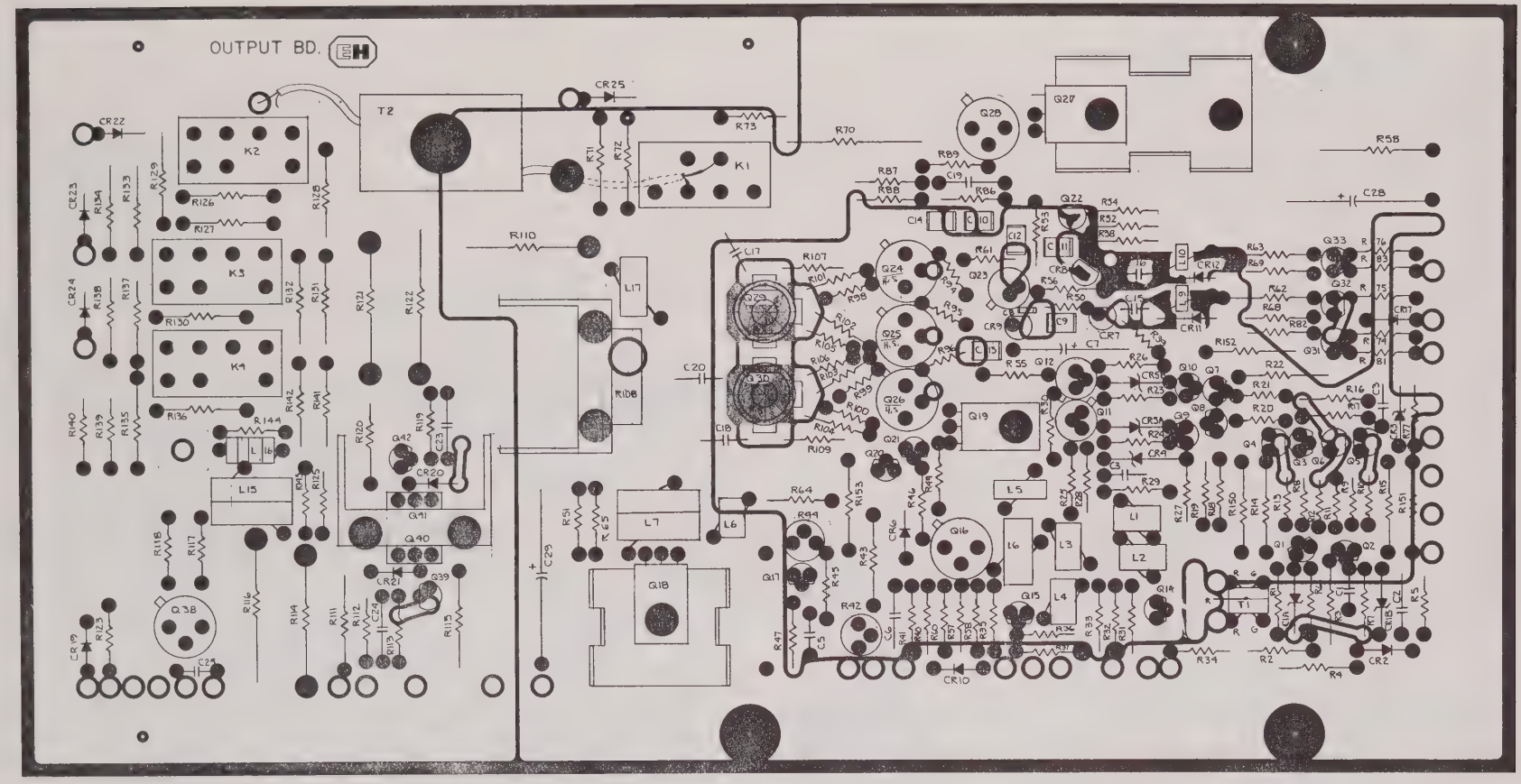


POWER SUPPLY REGULATOR BOARD SCHEMATIC

(A)

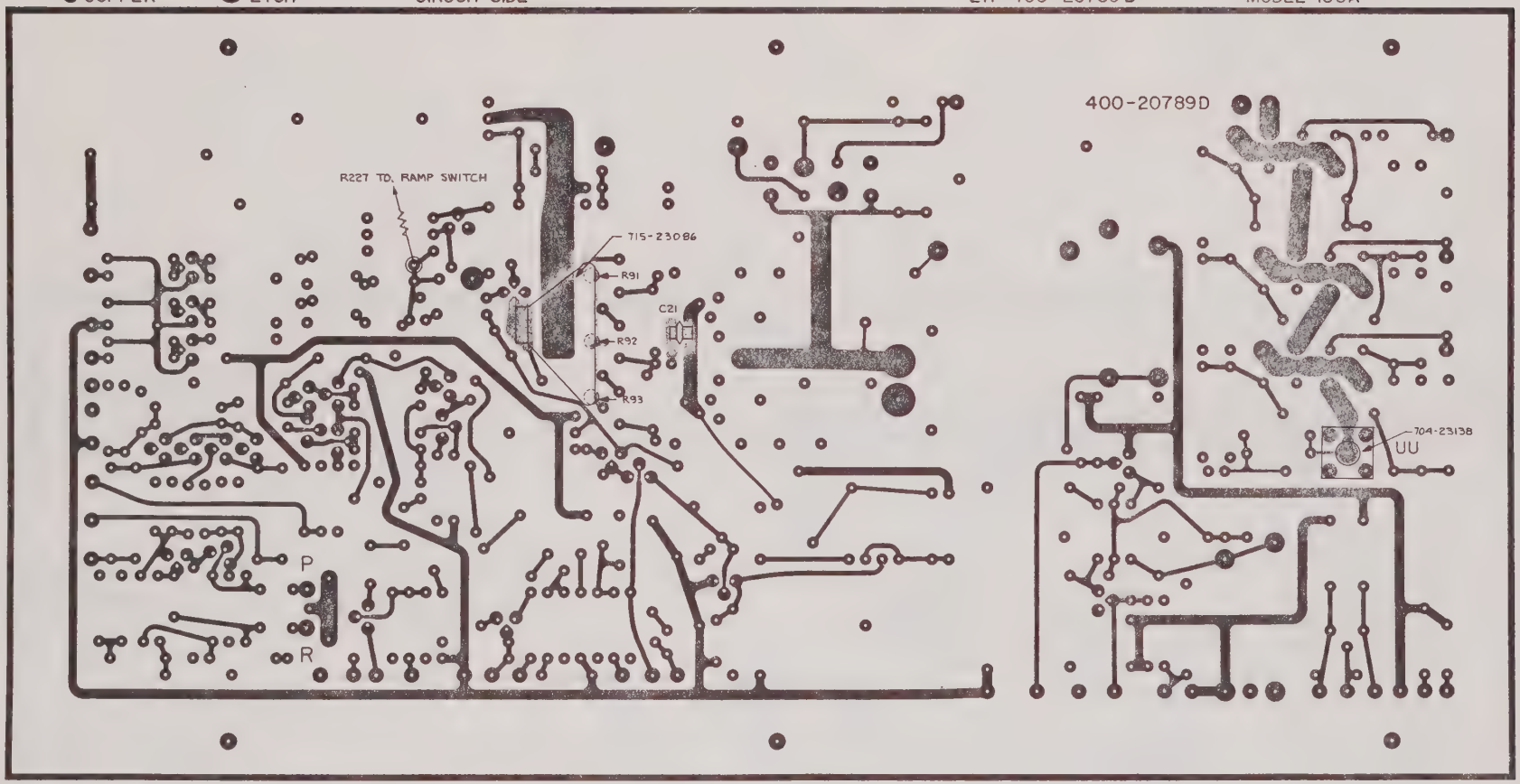
D-140-15317

COMPONENT SIDE

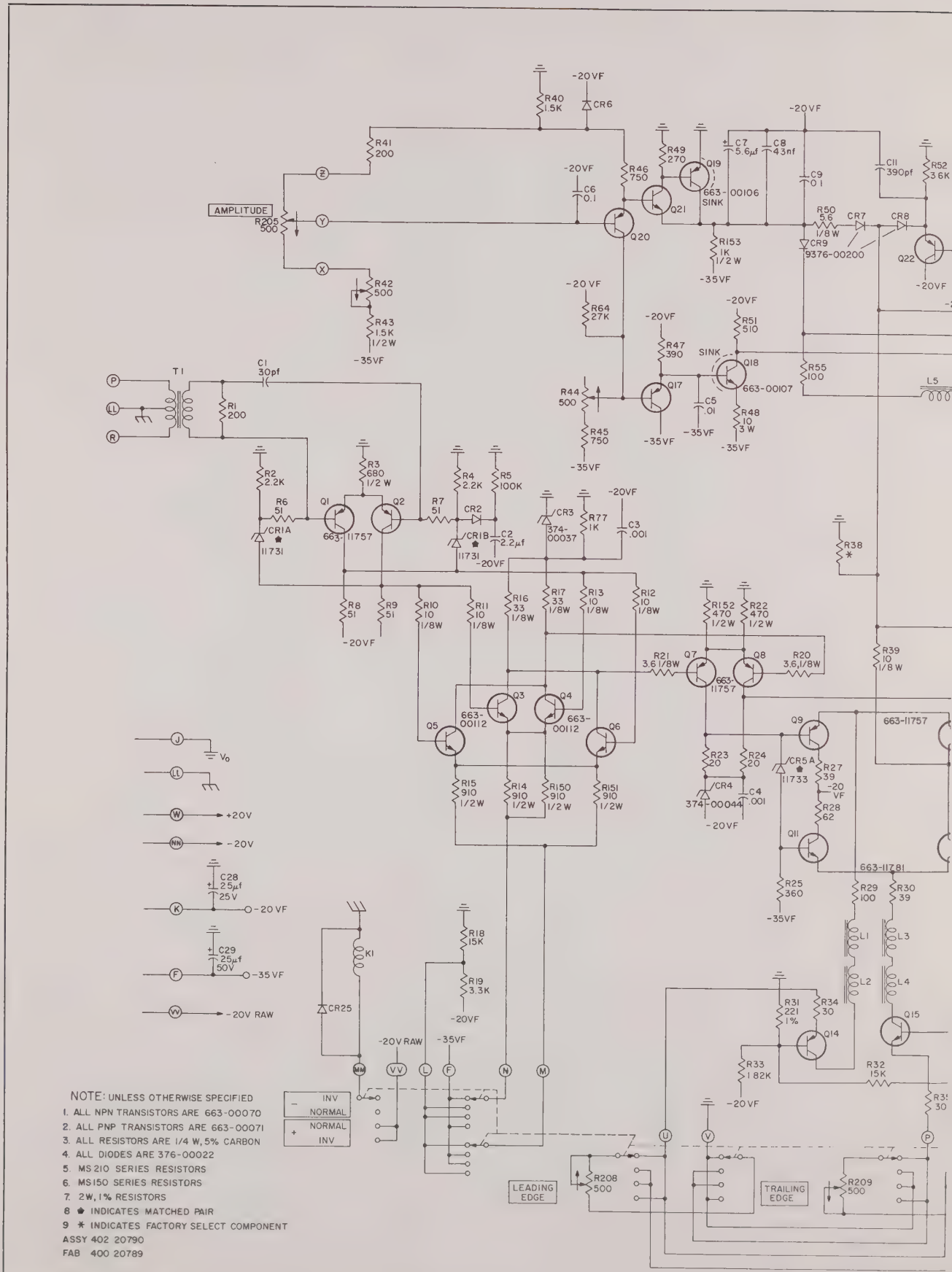


EH	ASSEMBLY DRAWING OUTPUT BOARD			
MODEL NO. 135A		CHARGE NO: EP 697		ISSUE
DRAWN BY		4.18.72	D- 402 - 20790	A
TAPED				
CHECKED		4/18/72		
APPROVED		4-18-72	SHEET NO. 1 OF 2	

● COPPER ○ ETCH CIRCUIT SIDE EH-400-20789 D MODEL 135A



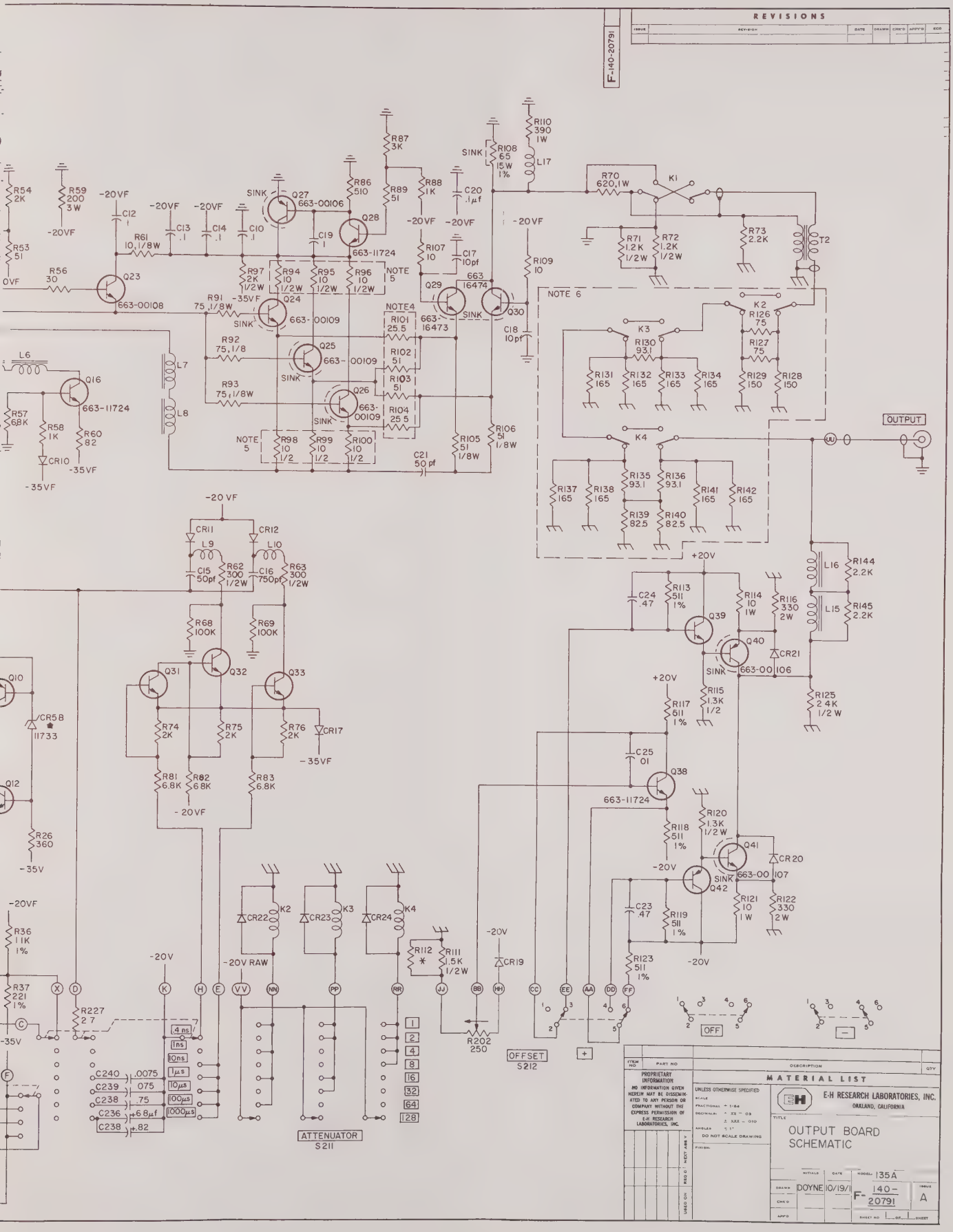
ASSEMBLY DRAWING OUTPUT BOARD				
MODEL NO 135A		CHARGE NO: EP697		ISSUE
DRAWN BY	AM	4.24.72	D- 402- 20790	A
TAPED				
CHECKED		4.24.72		
APPROVED			SHEET NO. 2 OF 3	



NOTE: UNLESS OTHERWISE SPECIFIED

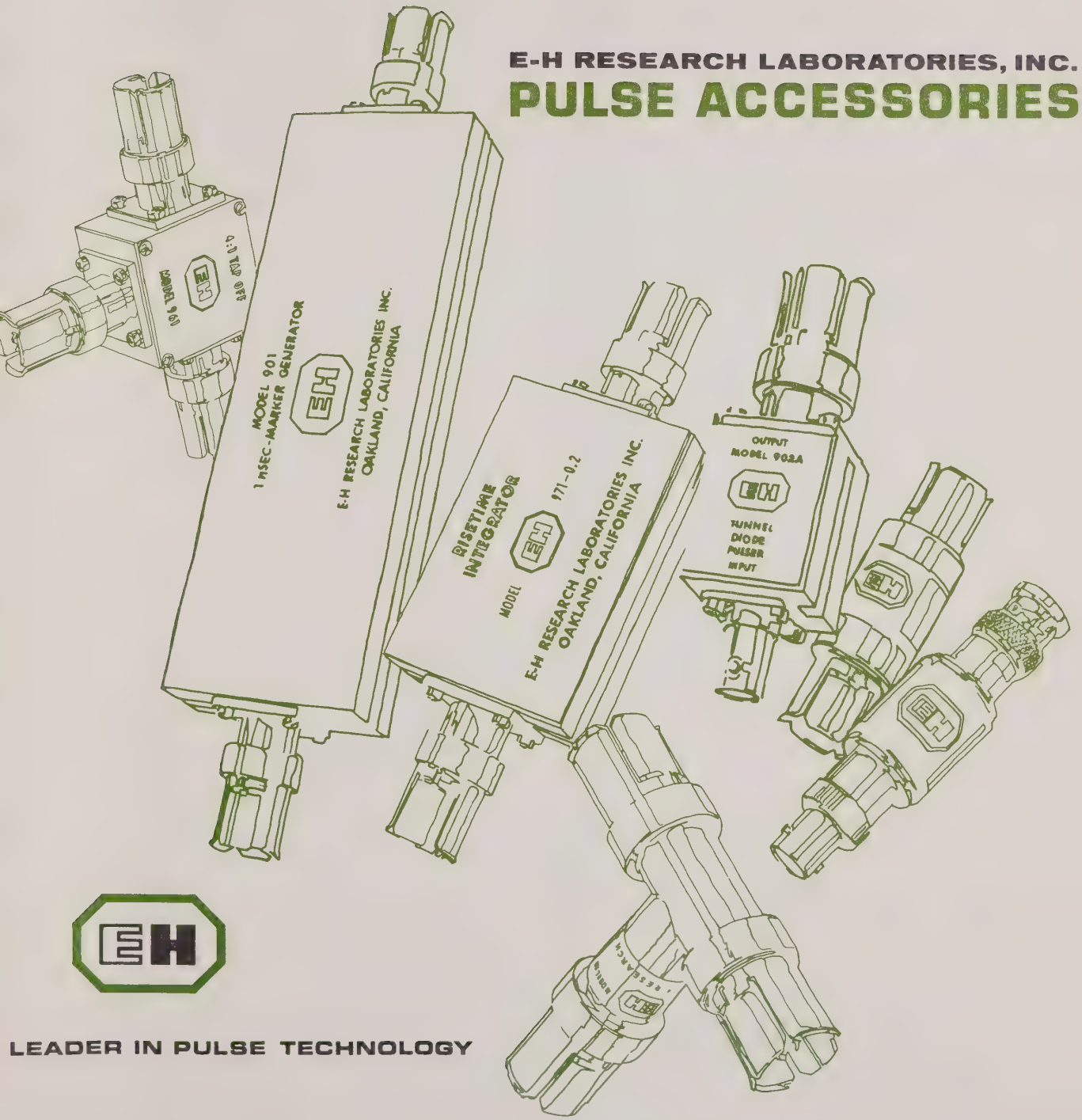
1. ALL NPN TRANSISTORS ARE 663-00070
2. ALL PNP TRANSISTORS ARE 663-00071
3. ALL RESISTORS ARE 1/4 W, 5% CARBON
4. ALL DIODES ARE 376-00022
5. MS 210 SERIES RESISTORS
6. MS 150 SERIES RESISTORS
7. 2W, 1% RESISTORS
8. ● INDICATES MATCHED PAIR
9. * INDICATES FACTORY SELECT COMPONENT

ASSY 402 20790
FAB 400 20789


REVISIONS
F-140-20791
R54 2K
R59 200 3W
R53 51
-20VF
-35VF
C12 1
C13 .1
C14 .1
C10 .1
R61 10,1/8W
R56 30
Q23 663-00108
R97 2K 1/2W
R94 10 1/2W
R95 10 1/2W
R96 10 1/2W
NOTE 5
Q27 663-00106
Q28 663-11724
C19 1
R86 510
R87 3K
R89 51
R88 1K
C20 .1µf
R107 10
C17 10pf
Q29 663 16474
Q30
C18 10pf
R108 65 15W 1%
R110 390 1W
L17
SINK
R109 10
R70 620,1W
K1
R71 1.2K 1/2W
R72 1.2K 1/2W
R73 2.2K
T2
NOTE 6
K2
R126 75
R127 75
K3
R130 93.1
R131 165
R132 165
R133 165
R134 165
R129 150
R128 150
K4
R135 93.1
R136 93.1
R137 165
R138 165
R139 82.5
R140 82.5
R141 165
R142 165
OUTPUT
R91 75 1/8W
Q24 663-00109
R92 75,1/8
Q25 663-00109
R93 75,1/8W
Q26 663-00109
NOTE4
R101 25.5
663-16473
R102 51
R103 51
R104 25.5
R105 51 1/8W
R106 51 1/8W
C21 50 pf
L6
L7
L8
Q16 663-11724
R57 68K
R58 1K
R60 82
CR10
-35VF
-20 VF
CR11
CR12
L9
L10
C15 50pf
R62 300 1/2W
C16 750pf
R63 300 1/2W
R68 100K
R69 100K
Q31
Q32
Q33
R74 2K
R75 2K
R76 2K
CR17
R81 6.8K
R82 6.8K
R83 6.8K
Q10
CR5B 11733
Q12
R26 360
-35V
+20V
C24 .47
R113 511 1%
Q39
R114 10 1W
R116 330 2W
Q40
CR21
SINK
663-00106
L16
L15
R144 2.2K
R145 2.2K
R115 1.3K 1/2
R125 2.4K 1/2 W
C25 01
Q38
663-11724
R117 511 1%
R118 511 1%
R120 1.3K 1/2 W
Q41
CR20
Q42
663-00107
R121 10 1W
R122 330 2W
C23 .47
R119 511 1%
R123 511 1%
R36 11K 1%
R37 221 1%
R227 2.7
C240 .0075
C239 .075
C238 .75
C236 +6.8µf
C238 +.82
.4 ns
1ns
10ns
1µs
10µs
100µs
1000µs
CR22
CR23
CR24
K2
K3
K4
-20V RAW
R112 *
R111 1.5K 1/2W
CR19
R202 250
OFFSET S212
ATTENUATOR S211
1
2
4
8
16
32
64
128
OFF
PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
OUTPUT BOARD SCHEMATIC
MODEL 135A
DRAWN DOYNE 10/19/1
F- 140-20791
ISSUE A

E-H RESEARCH LABORATORIES, INC.

PULSE ACCESSORIES



LEADER IN PULSE TECHNOLOGY

model 901 MARKER GENERATOR

The Model 901 Marker Generator is designed to convert a fast risetime voltage step into a train of time markers spaced precisely 1 nanosecond apart. The voltage output is proportional to the second time derivative of the leading edge of the input pulse.

SPECIFICATIONS

Marker Period . . . . . 1 nanosecond

Input Pulse Requirements . . . . . approx. 100 ps risetime; pulse width greater than total markers to be used.

Marker Accuracy . . . . . ±0.3% non-cumulative from one marker to the next. Marker intervals are measured from either the peaks or the crossover point. Accuracy of ±0.1% is available on request.

Output Termination . . . . . 50 ohms

Input Termination . . . . . 50 ohms

Maximum Input Power . . . . . 0.1 watt minimum average

Attenuation Factor . . . . . each marker's amplitude is approximately 1 dB down from previous marker.

Price $220

model 902A TUNNEL DIODE PULSER

The Model 902A contains a tunnel diode mounted in a high-frequency strip-line and supplies a 450 millivolt output with a risetime less than 100 picoseconds. This device may be driven with any period function such as a sine wave, square wave, ramp, etc. The Model 902A requires no power source other than its drive input.

SPECIFICATIONS

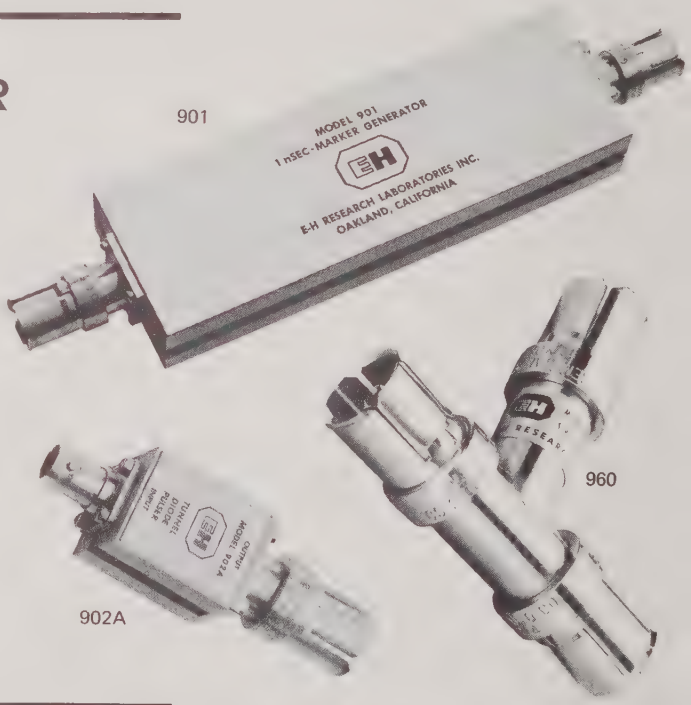
Polarity . . . . . negative; positive on request

Pulse Distortion . . . . . less than 10% (typically 5%)

Minimum Input Amplitude . . . . −5 volts peak into 50 ohms

Maximum Peak Voltage Input . . . . . 15 volts

Price $190



model 960 100:1 TAP-OFF

The Model 960 is a unique accessory in our product line: it is now possible to terminate a pulse system into 50 ohms and still observe the waveform without using the 50-ohm input impedance of the sampling oscilloscope as the load. This permits a 1 A pulser to be terminated with an adequate load, and still allows the pulse waveform to be observed without introducing distortion into the system.

The 960 has a risetime of 100 ps which is adequate for use with fast risetime pulsers such as the E-H Model 125A. With the advent of the 125A pulse generator and the 960 tap-off, an effective time domain reflectometry system may be set up with the use of the sampling scope.

SPECIFICATIONS

Risetime Input to Sidearm . . . . . less than 100 ps

Distortion Introduced Input to Output . . . . . less than 2%

Tap-Off Ratio . . . . . 100:1, ±3% into matched sidearm

Tap-Off Termination . . . . . oscilloscope connection must be terminated in 50 ohms for 100:1 ratio

Tap-Off Arm Distortion . . . less than 2% on 300 ps time scale
less than 6% on 100 ps time scale

Duty Cycle . . . . . 25% at 50 volts

Connectors . . . . . General Radio Type 874

Price . . . . . $ 90

model 961 *TDR TAP-OFF*

The 961 TDR Tap-Off is a 50-ohm line-sampling device designed to be used for time-domain reflectometry with the E-H Model 125A Pulse Generator. It delivers a 6 volt 300 ps step to the device under test with a 4:1 monitor tap-off ratio.

SPECIFICATIONS

Risetime Input to Sidearm ..... less than 300 ps

Distortion Introduced Input to Output ..... less than 2%

Input to Output Ratio ..... 1.66:1 ±5% (10–6)

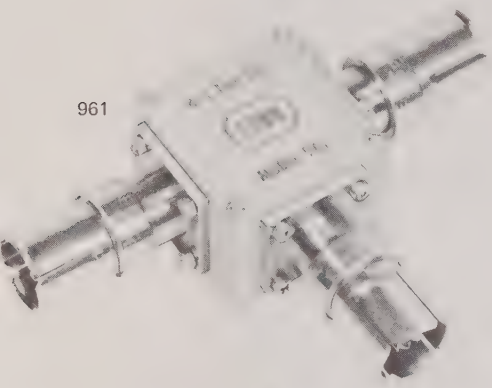
Tap-Off Ratio ..... 4:1 ±5% (output to arm)

Tap-Off Termination ..... 50 Ωscope input impedance forms the completion of arm

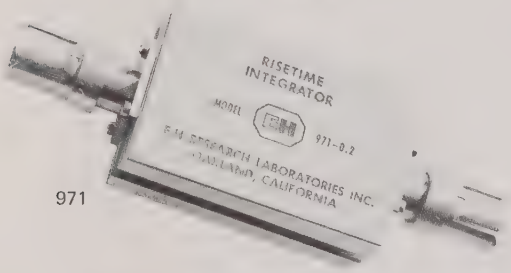
Tap-Off Arm Distortion ..... less than 2% on 300 ps time scale

Duty Cycle ..... 10% at 10 V, maximum

Price $190



961



971

model 971 *RISETIME INTEGRATOR*

The Model 971 is a precision 50-ohm strip-line low-pass filter which is a useful pulse generator accessory for integrating fast-rising pulses to slower, precisely known, rise and fall times.

The Model 971 is made up of four half-section constant-k low-pass filters and is balanced so that either port may be used as an input. The specified risetime of the device is dependent on having an input much faster than its output risetime. A general rule would be to require the input to be ten times faster than the specified output. For inputs that do not meet this requirement, the resultant output risetime is equal to the square root of the sum of the squares of the input pulse risetime plus the risetime of the Model 971.

SPECIFICATIONS

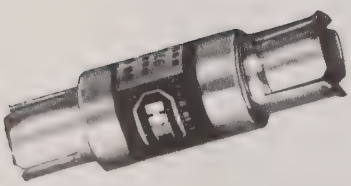
Input Pulse Polarity ..... positive or negative

Risetime ..... 0.2 ns, 0.5 ns, 1 ns, 2 ns and 5 ns

Accuracy ..... ±10% from 10% to 90% points with an input ten times faster than the specified output risetime.

Overshoot ..... less than 5%

Price $170



972

model 972 *PULSE TRANSFORMER*

The Model 972 is a 50-ohm to 50-ohm inverting transformer which has an extremely fast risetime. The 972 was designed primarily to invert the 120E pulse generator output but will find many other useful applications in pulse work, such as dc isolation, and matching which requires 1:1 impedance ratios.

SPECIFICATIONS

Risetime ..... less than 0.25 ns

Distortion ..... 5% on a 300 ps time base

Pulse Width ..... maximum 1 μs at 10 V with 37% droop.

Price ..... $ 90

model DT DC RESTORER

This diode device eliminates baseline shift in ac-coupled, nanosecond-pulse systems. The Model DT clamps to 0 volts.

SPECIFICATIONS

Peak Input ..... 20 V

Attenuation ..... approximately 10%

Uses ..... DTP for positive pulses, DTN for negative pulses.

Price ..... $ 60

model RT RISETIME INTEGRATOR

This device is used to produce known, repeatable, fixed times from a fast pulse input.

SPECIFICATIONS

Standard Times ..... 5, 10, 20, 50, 100 ns (special times available on request)

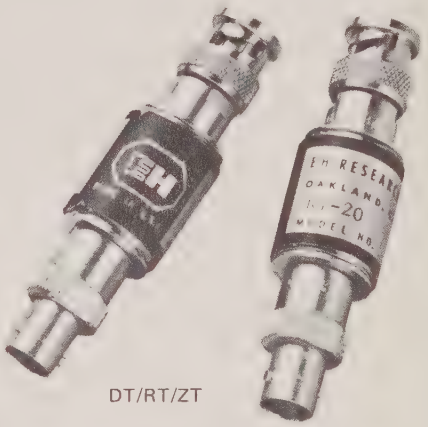
Accuracy ..... ±10%

Maximum Average Input ..... 500 mA

Connectors ..... BNC

Specify risetime when ordering (e.g., RT-10 = 10 ns).

Price ..... $ 35



DT/RT/ZT

model ZT PULSE TRANSFORMER

This nanosecond transformer is used for impedance matching or inversion. Impedances of 50, 93, 125, 185, or 200 ohms are available. Any combination input to output with or without inversion can be accomplished. BNC connectors are provided.

ORDERING INFORMATION FOR THE MODEL ZT

Input Impedance: specify first digit if below 100 ohms or first two digits if 100 ohms or above.

Output Impedance: same as above.

Inversion: if inversion is required add an X at the end of the model number.

Example: Model ZT-5-20X: 50 ohms input impedance; 200 ohms output impedance; inverted output.

Price ..... $ 35

967

model 967 ATTENUATOR

The E-H Model 967 Variable Attenuator is a 50-ohm high power switching attenuator for fast-pulse systems.

Features of the 967 include:

1. Less than 2% pk–pk clutter at 5 ns
2. 1/2/5/10/20/50/100:1 steps
3. 25 watt average dissipation

Price $290

E-H RESEARCH LABORATORIES, INC.

515 11th Street • Box 1289, Oakland, California 94604 • (415) 834-3030 • TWX 910-366-7258
In Europe: E-H Research Laboratories (Ned) N.V., Box 1018, Eindhoven, The Netherlands, Telex 51116
In Japan: Iwatsu Electric Co., Ltd., No. 7-41, 1-chrome Kugayama Suginami-Ku, Tokyo 167, Japan

TP5M/PA1272

Prices and technical data subject to change without notice – All prices F.O.B. Oakland, California

CHANGE INFORMATION

The following types of changes are found in this Section:

Corrections--
changes due to errors in text or illustrations

Additions--
new text or new illustrations to supplement original manual

Revisions--
new text or new illustrations to up-date original manual

Options--
information on non-standard accessories or options available for this instrument

Modifications--
information on special features of a custom-designed instrument

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